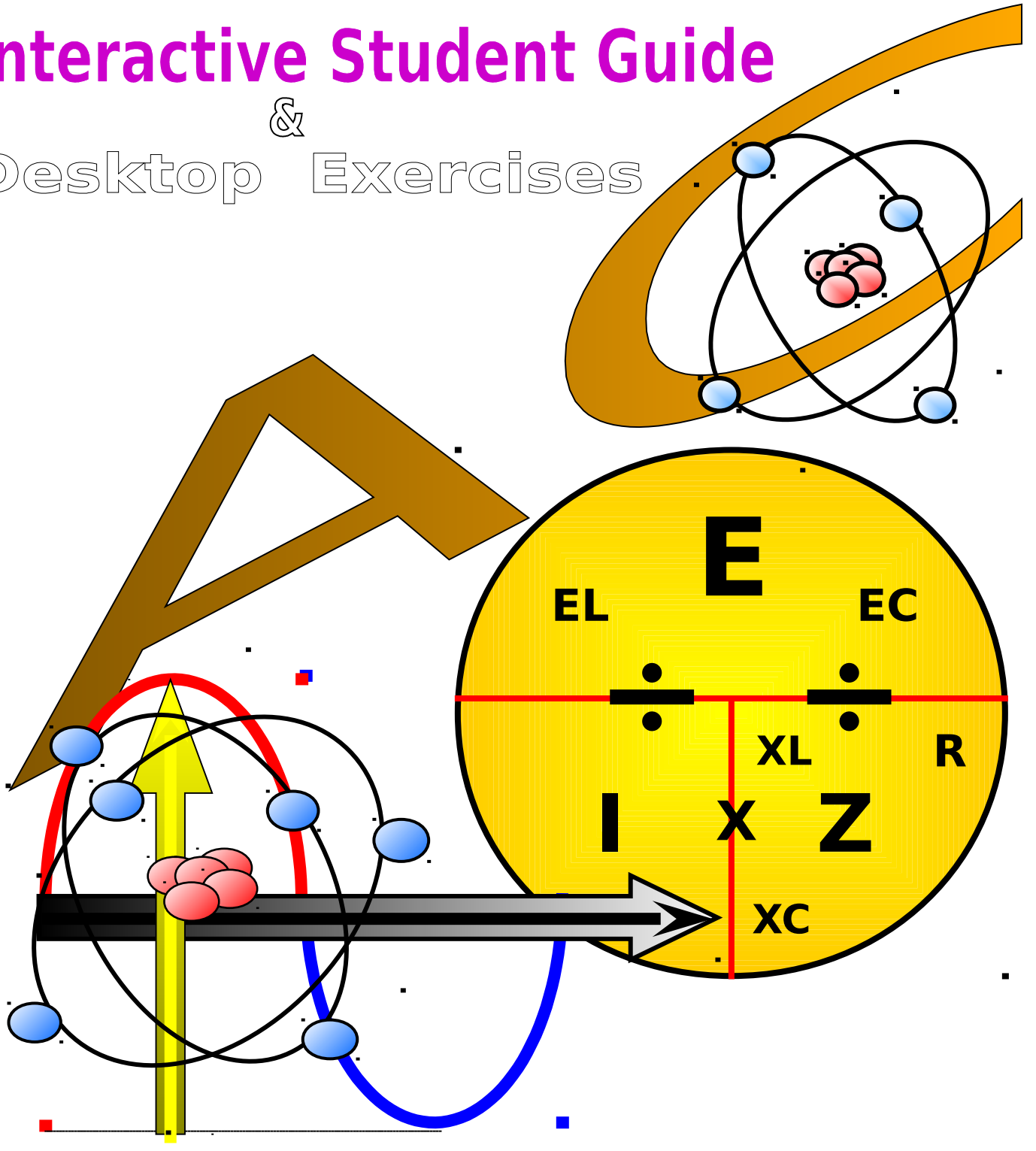
UNITED STATES ARMY OMEMS

Redstone Arsenal,AL.

Interactive Student Guide

&

Desktop Exercises



Version Ia. W/updated Test Equipment **7 Nov 03**

Add Glossary, Index, Condensers, CF351, Sld. Ref, 7 Nov 2003

IPR SR Staff; 17 Oct 03 post corrections, Intro to RL Trans

Revisions; Oct 03 Version Ib

Run validation on new F-Gen; 27 Aug 03Mr. Odom

Add; New Sweep Generator 18 Aug 03 160 Pg

3rd Draft June 2003

Super Review: Mr. C. R. Patrick

Student Validation: 18 Nov 02 TO Present

Ac Test Equip added 25 Feb 03 154 Pg

2nd Draft Revision VIS 23 Dec 02 141 Pg

2nd Draft 18 Nov 02 141 Pg

1st Draft 24 Oct 02

002

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AC:

Sinewave;

Is the Voltage Generated in relation to the angle or position of the rotor in the magnetic field.

Period;

The amount of time required for the rotor to make 1 complete revolution. In units of Seconds [Sec], [μS]

Frequency;

Is the number of complete revolutions [360o] of the Generator in 1 Second. Unit of Measure; Hertz, (Hz & KHz).

μ **Sec**
KHz

m Sec Hz

Note; Only Period can be measured on the O Scope.

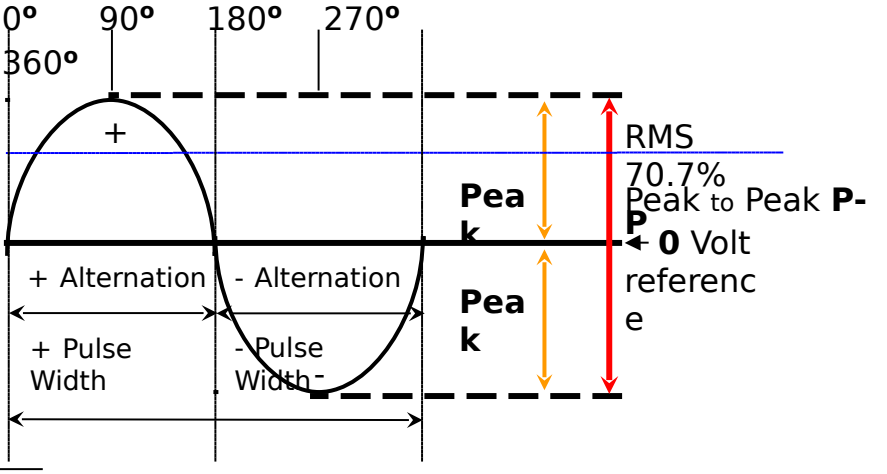
Period to **Frequency;**

If Period is known, Frequency can be calculated.
1/ Period or [**Period 1/X**] ⇒ Freq In [Hz]

Frequency to **Period;**

Frequency to Period; If Frequency is known, Period can be calculated.
1/Freq or [Freq 1/X] ⇒ Period In [SEC]

Sinewave Profile;

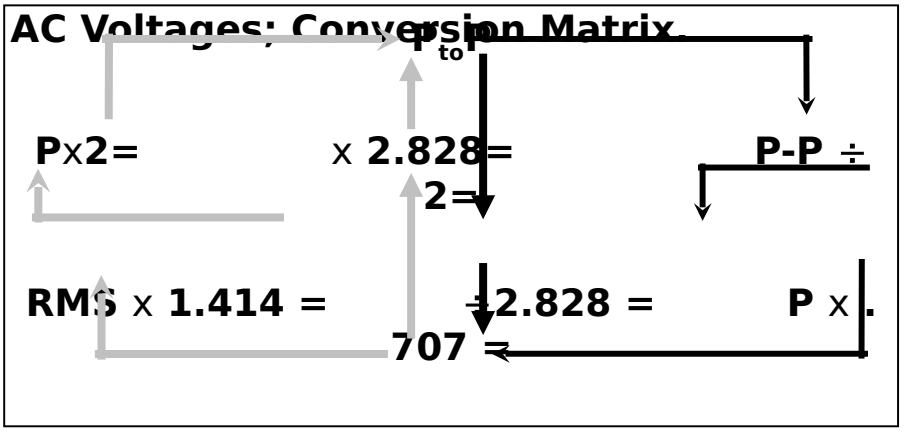


AC Voltages Conversion;

P-P ÷ 2 = Pk.
P x .707 = RMS
RMS x 1.414 = Pk.
Px2 = P-P

P-P ÷ 2.828 = RMS

AC Voltages; Conversion Matrix.



AC: CONDENSERS.
INDUCTORS.

Inductor;

Opposes any change in Current & stores energy in an Electromagnetic Field.

Unit of Measure;

Symbol; **L**
Unit of Measure; henrys, **h** *lower case* , **mh** milli henrys
3 Types; Air Core, Iron Core, Variable.

LT
L in Series

Are Additive Like Resistors in **Series**,
(L1 + L2 + L# = LT).

LEQ
L in Parallel

Are calculated Like Resistors in **Parallel**,
(L1 1/X + L2 1/X = 1/X = LEQ).

LT
L in Series-Parallel

Are calculated Like Resistors in **Series-Parallel**, **(LEQ + Inductors in series = LT).**

XL;

Inductive Reactance;

Reactance; Because the Inductor is a Frequency sensitive device, it will change in value of opposition as the Frequency changes. Since its value cannot be measured, it has to be calculated, with frequency as part of the equation.

Reactance, Symbol; X Unit of Measure; Ω Ohms
Inductive Reactance; XL Unit of Measure; Ω Ohms

Formula; X_L

"2 Pies For Lunch"
2 π F L
2 π X Frequency X Inductor

2 π = 6.28

Freq=10KHz L= 5 mh

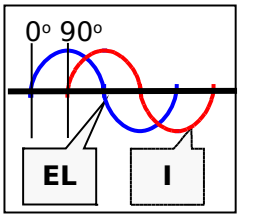
On the **Calculator;**

2 π x 10 KHz x 5 mh = XL in Ω

X_L **= 6.28 X 10 EE 3 X 5 EE-3 = 314.** Ω

Phase Relationship;

Voltage [EL] Leads Current by 90°



Memory Aid;

E L I the ice man is 90 years old

Phase Relationship; continued.

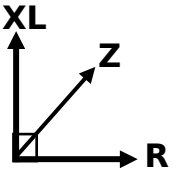
$2\pi F L = X_{LT}$ in Ω

A DIRECT RELATIONSHIP exists between the **XL** and Frequency and the size or Value of the Inductor.

A DIRECT RELATIONSHIP exists between the **XL** & **EL**

If; **F** ⇑ or **L** ⇑ then **XL** ⇑ and the **EL** ⇑.

IMPEDANCE;



Total opposition to AC. With a circuit containing non-reactive & reactive components they are added using Vectors. Unit of measure; **Ω,** Symbol; **Z**

$$Z = \sqrt{R^2 + X_L^2} \quad \text{or} \quad Z = \sqrt{R_T^2 + X_{LT}^2}$$

On the **Calculator;**

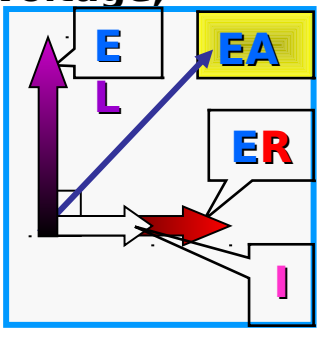
R X^2 + XL X^2 = $\sqrt{X}$ ⇒ Z in Ω

Example;

If; **R= 5Ω** & **XL = 376 Ω;** then **Z =** $\sqrt{\quad}$ **5Ω² + 376 Ω²**

5 Ω X^2 + 376 Ω X^2 = X ⇒ 376.033 Ω

Applied Voltage;



Because opposition was added vectorally, the individual voltage drops must be added vectorally

$$EA = \sqrt{E_{RT}^2 + E_{LT}^2}$$

E_R X^2 + E_L X^2 = $\sqrt{\quad}$ X ⇒ EA

Sequential Order; Problem Solving

$X_{LT} = 2\pi F L_T$

$R_T = R_1 + R_2$

$Z_T = \sqrt{R_T^2 + X_{LT}^2}$

$I_T = EA \div Z$

$E_{R\#} = I_T \times R_\#$

$E_{L\#} = I_T \times X_{L\#}$

$EA = \sqrt{E_{RT}^2 + E_{LT}^2}$

AC: CONDENSERS.
CAPACITORS.

Capacitors;

Opposes any change in Voltage & stores energy in an Electrostatic Field.

Symbol; **C**

Unit of Measure; Unit of Measure; **Farads**, **f** *lower case* , **µf** micro farads

3 Types; Fixed value, electrolytic, Variable.

CEQ Parallel Caps in Parallel is Additive Like Resistors in **Series**, **(C1 + C2 + C# = CT).**

CT Series Caps in Series is calculated Like Resistors in **Parallel**, **(C1 1/X + C2 1/X = 1/X = CEQ).**

CT Series-Parallel Caps in parallel portion are additive to = CEQ. The CEQ is now in series w/ the other series Cap (s). Both are calculated like caps in parallel. **(C1 1/X + CEQ 1/X = 1/X = CT).**

XC;

CAPACITIVE REACTANCE;

Because the capacitor is a frequency sensitive device, it will change in value of opposition as the frequency changes. Since its value cannot be measured, it has to be calculated, with frequency as part of the equation.

Reactance, Symbol; X Unit of Measure; Ω Ohms

Capacitive Reactance; XC Unit of Measure; Ω Ohms

Formula; X_C

"1 over 2 Pies For chow"

$$\frac{1}{2\pi F C}$$

2 π X **Frequency** X **Capacitor 1**/X

On the **Calculator;**

2 π = 6.28

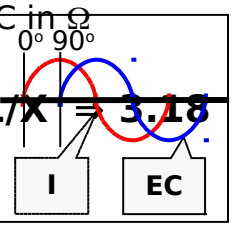
Freq= 10KHz L= 5 µf

2 π x 10 KHz x 5 µf = XC in Ω

Phase Relationship;

X_C **= 6.28 X 10 EE 3 X 5 EE -6 1/X = 3.18**

Ω



Voltage [EC] LAGS Current by 90°

Memory Aid;

E Li the I C E man is 90 years old

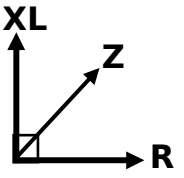
Phase Relationship; continued.

An **INDIRECT RELATIONSHIP** (or opposite) exists between the **XC** and Frequency and the size/ Value of the Capacitor.

A Direct relationship exists between the **XC** & **EC**

If; **F** ↑ or **L** ↑ then **XL** ↑ and the **EL** ↓.

IMPEDANCE;



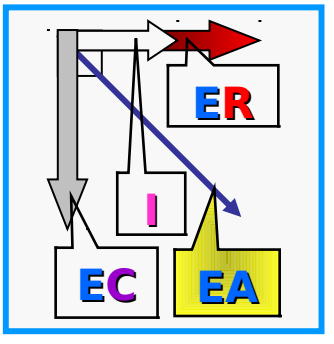
Total opposition to AC. With a circuit containing non-reactive & reactive components they are added using Vectors. Unit of measure; **Ω,** Symbol; **Z**

$$Z = \sqrt{R^2 + X_C^2} \quad \text{or} \quad Z = \sqrt{R_T^2 + X_{CT}^2}$$

On the **Calculator;**

R X^2 + XC X^2 = $\sqrt{x}$ ⇒ Z in Ω

Applied Voltage;



Because opposition was added vector-ally, the individual voltage drops must be added vector-ally

$$EA = \sqrt{E_{RT}^2 + E_{CT}^2}$$

E_R X^2 + E_C X^2 = $\sqrt{x}$ ⇒ EA

Sequential Order; Problem Solving

$$X_{CT} = \frac{1}{2\pi F C_T} \qquad E_{C\#} = I_T \times X_{C\#}$$

$$R_T = R_1 + R_2 \qquad EA = \sqrt{E_{RT}^2 + E_{CT}^2}$$

$$Z_T = \sqrt{R_T^2 + X_{CT}^2}$$

$$I_T = EA \div Z$$

$$E_{R\#} = I_T \times R_{\#}$$

AC: CONDENSERS.
RC TRANSIENT.

Transient Waveform;

A waveform that changes from one steady state to another or is positive for a period of time, then Negative for an equal period of time. A Sine wave is not a transient waveform.

Square Triangular Saw tooth Spike

RC Ckt;

A Ckt comprising of a Resistor & Capacitor in series where the rate [time] of Charge & Discharge is dictated by the value [size] of the Resistor & Cap.

1 Time Constant [TC]

1 TC is the amount of time required for a Capacitor to charge to 63% of the applied. 5 TC will charge a cap to 100%.

TC = R X C in Micro Seconds only, µS .

Pulse Width;

$$PW = \frac{1}{2F} \qquad PW = \frac{1}{2 \times Freq}$$

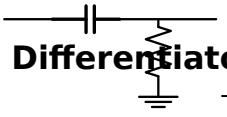
On the Calculator;

If Frequency; = 50 KHz
50 EE3 X 2 = 1/X ⇒ .00001 Sec
PW = 10. µS

TC to PW Ratio;

The **TC** tells us how much **time is NEEDED** to charge a Capacitor to 63% of the Applied Voltage.
The **PW** tell us how much **time we HAVE** to charge a Capacitor to 63% of EA. Expressed as ratio in the lowest terms. 1/10, 10/1.

Circuit Types;

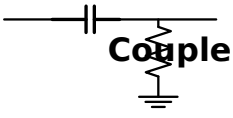


Differentiator;

Output taken across; Resistor
TC/PW ; Short
Output waveform; Spiked

Integrator;

Output taken across; Cap
TC/PW ; Long
Output waveform; Triangular



Coupler;

Output taken across; Resistor
TC/PW ; Long
Output waveform; Square

LR Ckt;

LR Ckt; A Ckt comprised of a Resistor & Inductor in series, where the rate [time] of Expansion & Contraction is dictated by the value [size] of the Resistor & Inductor.

TC;

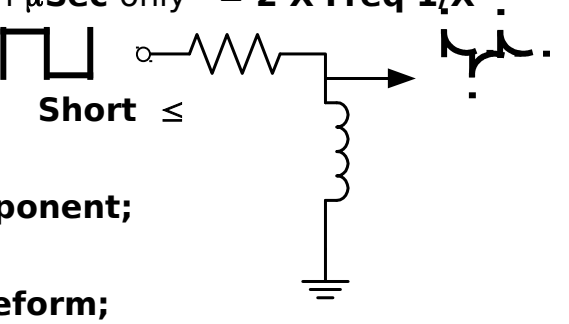
1 TC is the Time for current to reach approximately 63% of maximum expansion. 5 TC for 100%.

TC = L/R, In μ**Sec** only

Pulse Width; [PW]

PW In μ**Sec** only **= 2 X Freq 1/X**

Differentiator;

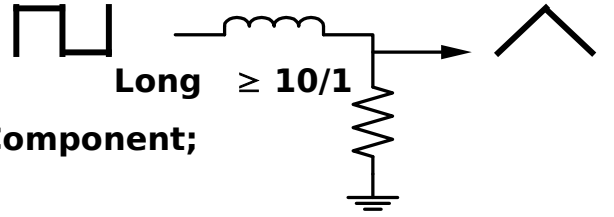


TC/PW; Short ≤ 1/10

Output Component; Inductor

Output Waveform; Spiked

Integrator;

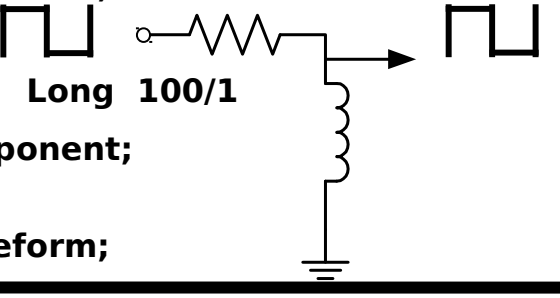


TC/PW; Long ≥ 10/1

Output Component; Resistor

Output Waveform; Triangular

Coupler;



TC/PW; Long 100/1

Output Component; Inductor

Output Waveform; Square

LCR;

Impedance;

Z

Is the total Opposition to AC, Unit Ω.
Because of the 180° Out Phase relationship of the XL & XC the difference must be calculated.
If they are Equal, they will cancel each other out, and only Resistance remains.

Formula;

$$Z = \sqrt{RT^2 + (XL - XC)^2}$$

On The Calculator;

XC - XL = X² + RT X² = √X

LCR; Cont;
Applied Voltage;

Because of the 180º Out Phase relationship of the EL & EC the difference must be calculated.
If they are Equal, they will cancel each other out, and only $\mathbf{E_{RT}}$ remains.

Formula;

$$\mathbf{EA = \sqrt{E_{RT}^{\ 2} + (EL - EC)^{\ 2}}}$$

On The Calculator;

EC – EL = X² + $\mathbf{E_{RT}}$ X² = √ X

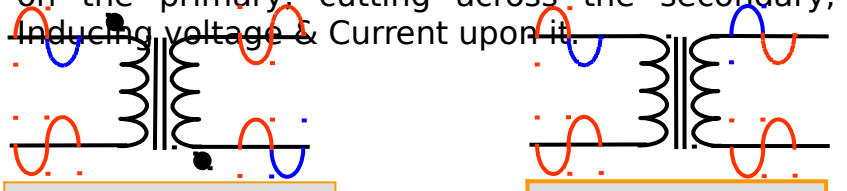
TRANSFORMER;

Mutual Inductance;

A transformer changes the AC input Voltage and Current from one value on the input to a different value on the output.

Mutual Inductance; The process of transferring the energy from the primary to the secondary due to the expansion & contraction of the magnetic field on the primary, cutting across the secondary, inducing voltage & Current upon it.

Phase;



180º Out of Phase | **IN Phase**

Step Up & Step Down;

Step Up & Step Down Refers only to Voltage, Current is the opposite.

Power;

Power in, is equal to, Power out. Transformers will be considered 100% efficient.

$$\mathbf{E_P \ X \ I_P = E_S \ X \ I_S}$$

Voltage (E) is stepped up, Current (I) is stepped down.
Power is a product of Voltage & Current, E X I = P

Power Supply;

Changes the AC Line Voltage to the required DC operating Voltages for the designated equipment. It can be + or **-** or both.

Rectifier;

Changes the AC output of the Transformer to PULSATING DC, In a + or **-** Half wave or + or **-** Full wave

Diode;

Sometimes referred to as a Crystal. Allows Current to flow in 1 direction, It acts like a one way valve, or one way Current device.

Advantages; Small in size, Low Voltage ops, Uses less power.

Disadvantages; Sensitive to Heat & High Voltage.

Letter Symbol;

CR or **D , CR1, 2, 3, …**

Schematic Symbol;

Bias;

Positive Material, ANODE CATHODE, Negative Material

Forward Bias;

Is the Difference of Potential between 2 points or Elements.

When the Polarity of the Signal agrees w/ the Polarity of the material.

Reverse Bias;

Current flow is Maximum, Resistance is Minimum.

When the Polarity of the Signal “Disagrees” w/ the Polarity of the material.

Current flow is Minimum, Resistance is Maximum.

½ Wave Rectifier;

Note: Current Flows against the Arrowhead, to the most positive point in the Ckt.

Full Wave Rectifier;

The position of the Diode in respect to the input will determine the polarity of the output. 1 diode makes it a ½ Rectifier. Frequency in = Frequency out.

Filter;

The Full Wave is identified by two diodes. Position of the diode in ref to direction of the input signal describes the output polarity. Only one diode conducts @ a time. Output freq is twice the input.

The Filter converts pulse-sating DC from the

AC: Commonly Used Acronyms.

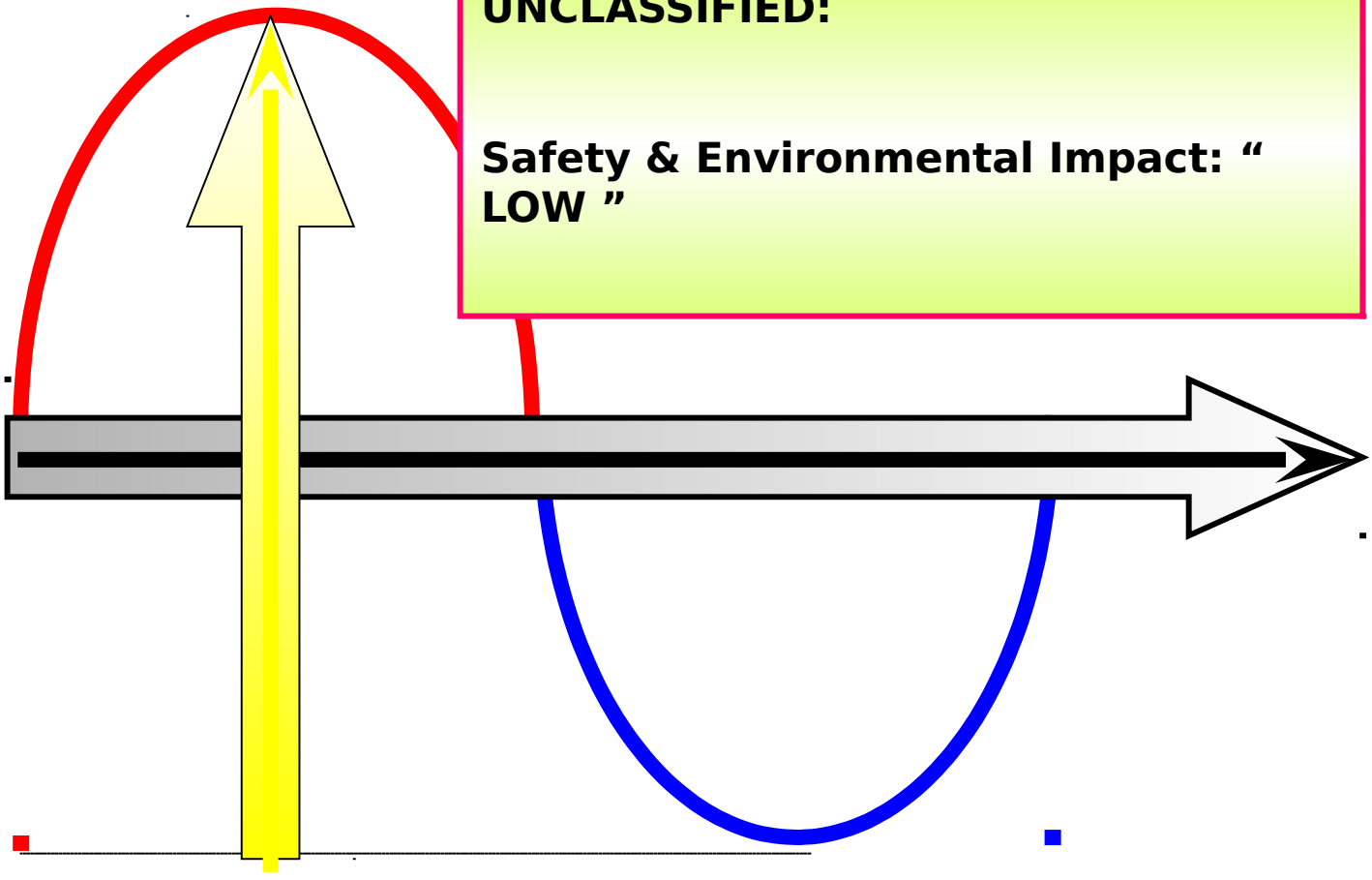
@	At
A/O	As Of
&	And
Ckt	Circuit
PWR	Power
W/	With
W/O	With out

Introduction To AC

& Frequency Calculations

UNCLASSIFIED:

Safety & Environmental Impact: “ LOW ”



Up to this point you have dealt with Direct Current, Current that is constant in magnitude & flows in one direction.

With this conference you will be introduced to the basic concepts & terms that define the principles of AC, Alternating Current.

Michael Faraday & Joseph Henry uncovered the first principles that defined AC for those that followed.

Our power grids & Communications are dependent upon AC.

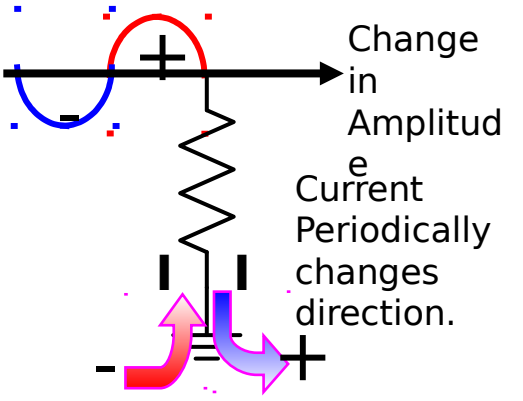
AC: Intro To AC & Freq; Concepts

AC;

Alternating Current, is current that flows in one direction then in the other.

Or Current that changes in Amplitude & Periodically reverses direction.

Current will still flow toward the most Positive point in the Ckt, the difference w/AC is, the polarity will alternately change.



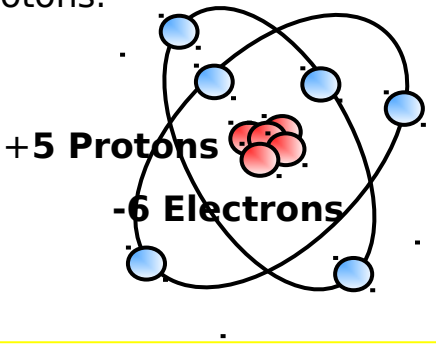
Magnetism; is the ability to attract Iron or Iron based Materials, [Ferrous Materials].

3 Types of Magnets;

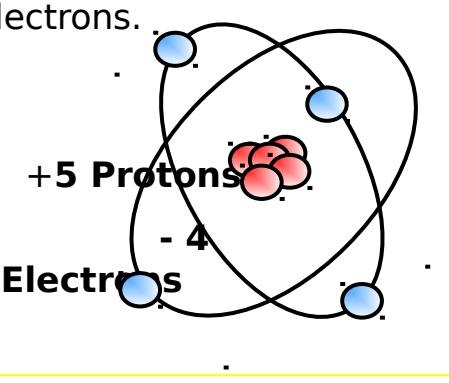
1. **Natural** [Magnetite]
2. **Permanent**
3. **Electromagnet** [Wire wrapped around an Iron core]

Atom; The smallest electromagnetic particle.

- ION; Atom has More **ELECTRONS** than Protons.

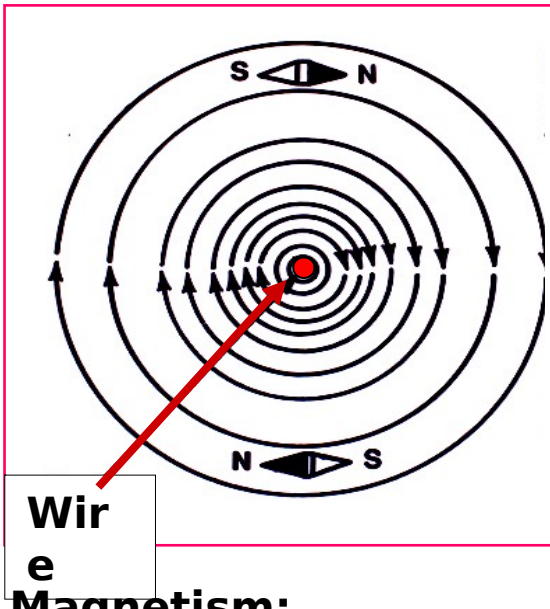


+ ION; Atom has More **PROTONS** than electrons.



AC: Intro To AC & Freq; Concepts

As Current flows through a conductor it creates a Magnetic Field or lines of Force, [Flux Lines].



Magnetic field is perpendicular to the Conductor [Wire]

Lines Form closed loops Lines do not cross

Lines become weaker as distance increases from the source.

Law of Magnetism;

Opposite poles or forces Attract.

Like poles or forces Repel.

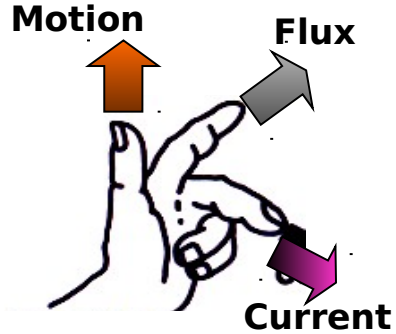
3 Requirements to Generate AC;

1. Motion.

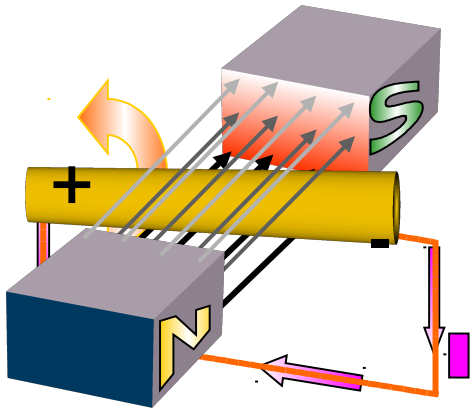
2. Magnetic Field [or Flux Lines**].**

3. Conductor [Wire**].**

Generator; **<u>Converts mechanical energy to electrical energy</u> by the conductor loop** [wire] **cutting through the Magnetic Field inducing Voltage & Current.**



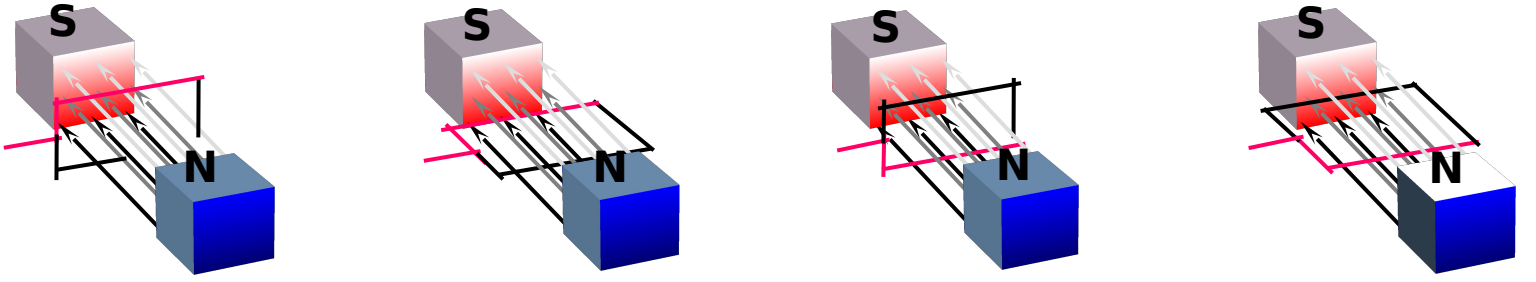
Left Hand Generator Rule

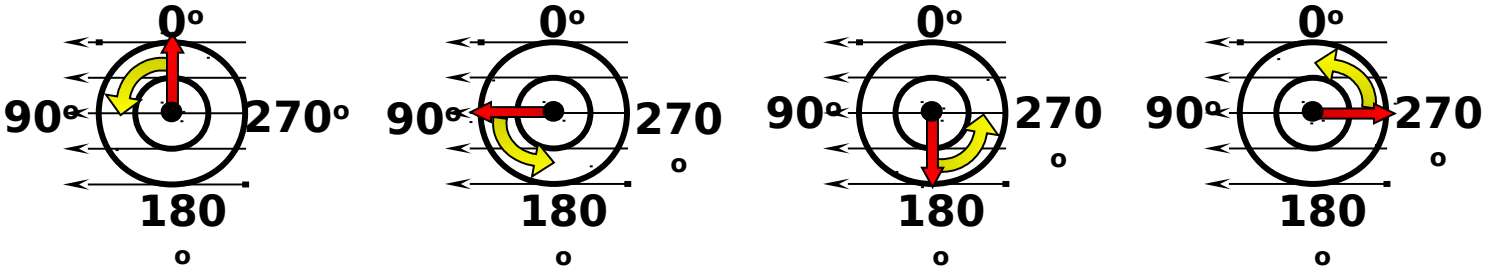


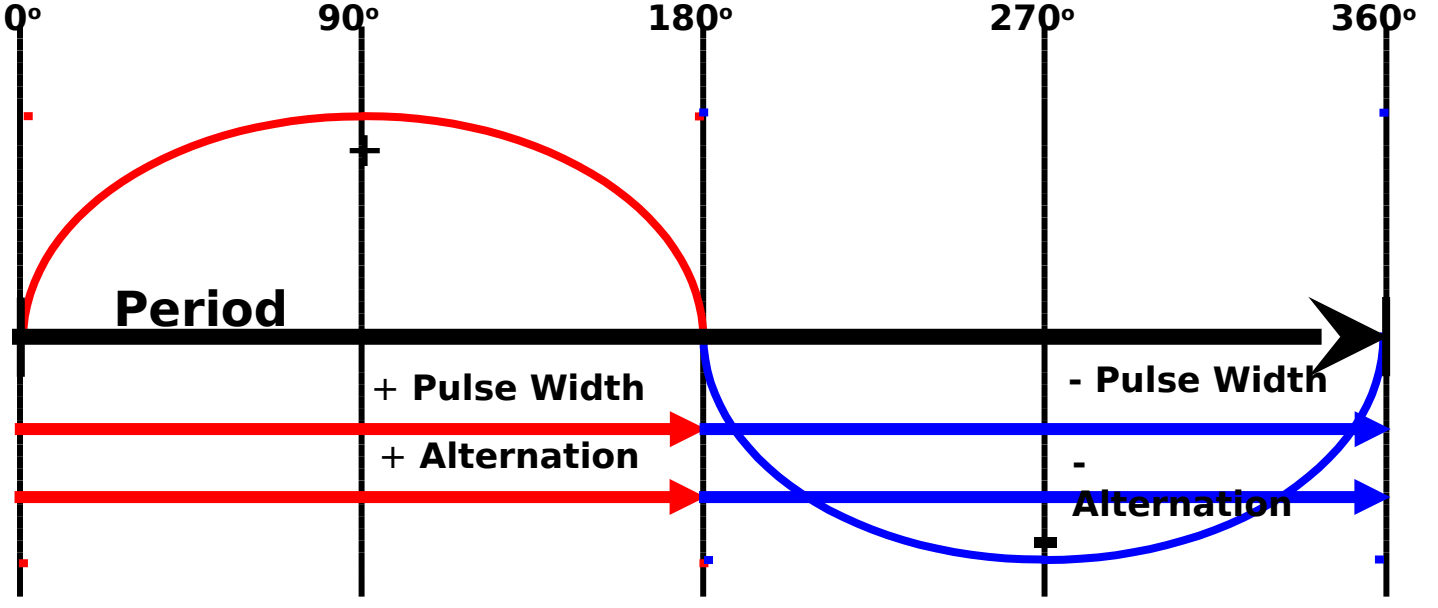
AC: Intro To AC & Freq; Period

Sinewave; Is the Voltage Generated in relation to the angle or position of the rotor in the magnetic field.

Period; Is the amount of time required for the rotor to make 1 complete revolution. In units of Seconds [Sec], [μS]



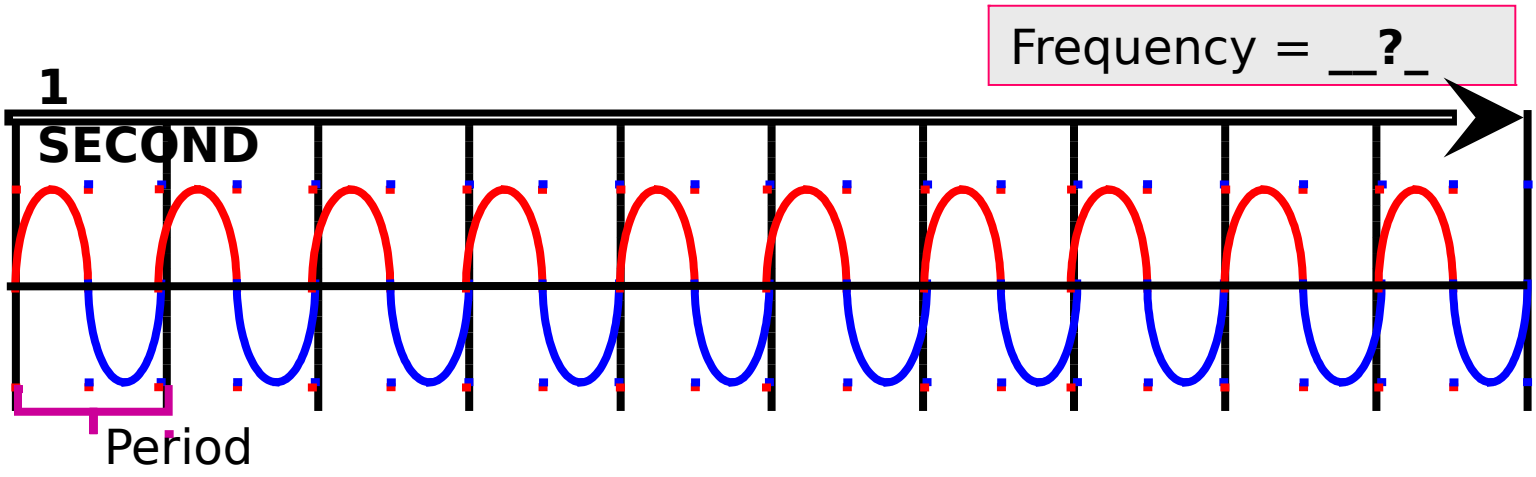




AC: Intro To AC & Freq; Frequency

Frequency; **Is the number of complete revolutions [360°] of the Generator in 1 Second.**

Unit of Measure; **Hertz, Hz, [KHz].** Note: Only Period can be measured on the O Scope.

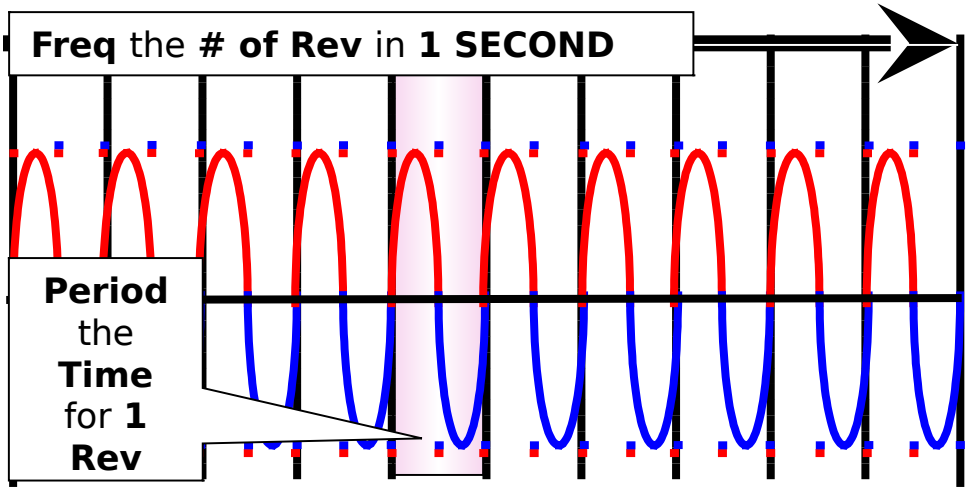


Period to Frequency; **If Period is known, Frequency can be calculated.**

1/ Period or [Period 1/X] ⇒ Freq In [Hz]

Frequency to Period; **If Frequency is known, Period can be calculated.**

1/Freq or [Freq 1/X] ⇒ Period In [SEC]



Frequency = 1 / Period = 1 / .1 Sec

.1 Sec 1/X ⇒ 10 Hz

Period = 1 / Freq = 1 / 10 Hz

10 Hz 1/X ⇒ .1 Sec

AC: Intro To AC & Freq; Review & Voltages

AC; Alternating Current, Current that changes in Amplitude & Periodically reverses direction.

3 Types of Magnets; 1. Natural [Magnetite] 2. Permanent 3. Electro.

Law of Magnetism; Opposite's Attract, Like's Repel.

Generator; Converts mechanical energy to electrical energy.

3 Requirements to Generate AC; 1. Motion, 2. Flux, 3. Conductor.

Sinewave; Is the Voltage Generated in relation w/the angle or position of the rotor in the magnetic field.

Period; The amount of time required for the rotor to make 1 complete revolution. In units of Seconds [Sec], [μS] .

Frequency; Is the number of complete revolutions [360°] of the Generator in 1 Second. In Units of Hertz, [Hz], [KHz].

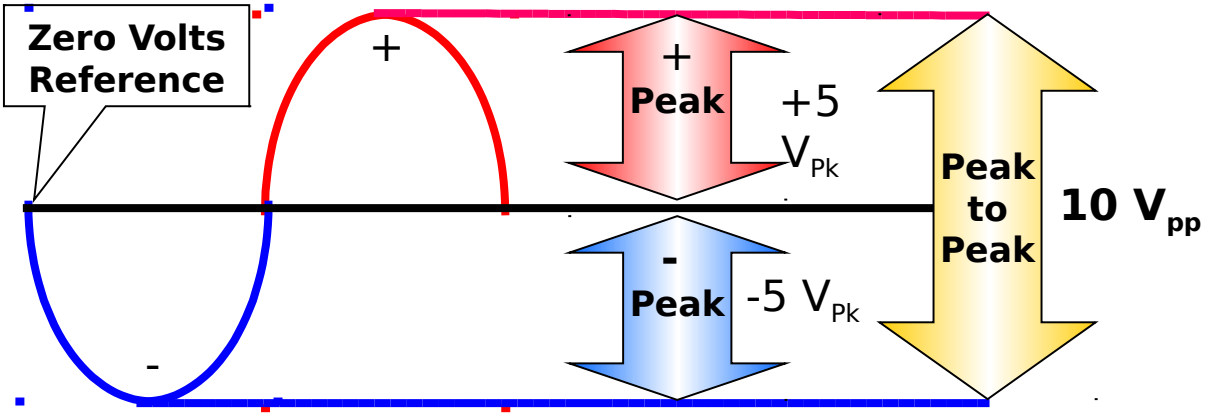
Period to Frequency; 1/ Period or [Period 1/X] ⇒ Freq In [Hz]

Frequency to Period; 1/Freq or [Freq 1/X] ⇒ Period In [SEC]

AC Voltages & Equivalent Values;

AC Voltage have 3 different numerical values for the same voltage.

1. Peak [pk]
2. Peak to Peak [PP]
3. RMS or Effective [VAC]



Peak X 2 = Peak to Peak

PP ÷ 2 = Peak

The O-Scope is used for P & PP measurements.

AC: Intro To AC & Freq; Voltages

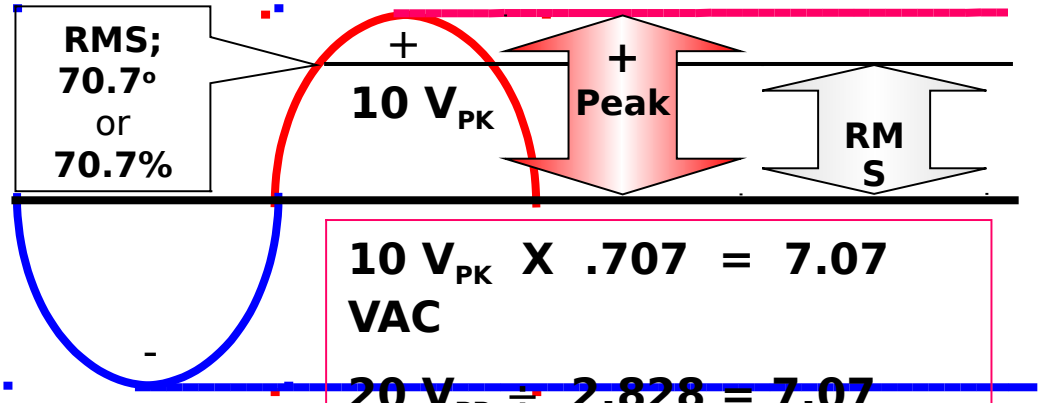
AC Voltages & Equivalent Values;

RMS; {Root Mean Square} **also Called the Effective Voltage** {EFF}**. Its name is derived from the constant .707 or 70.7% which is the value of percent of AC required to do the same work as DC.**

RMS, Read the Meter Student!

If a value of voltage is expressed as VAC it is professionally understood as the RMS / Eff AC Voltage.

If the AC voltage is Peak or Peak to Peak then the voltage MUST be labeled as such.



Peak X .707 = RMS or **EFF**

Pp ÷ 2.828 = RMS or **EFF**

10 V_{PK} X .707 = 7.07 VAC

20 V_{PP} ÷ 2.828 = 7.07 VAC

The DMM is used for RMS measurements.

AC Voltages & Equivalent Values Conversions;

PP ÷ 2 = P

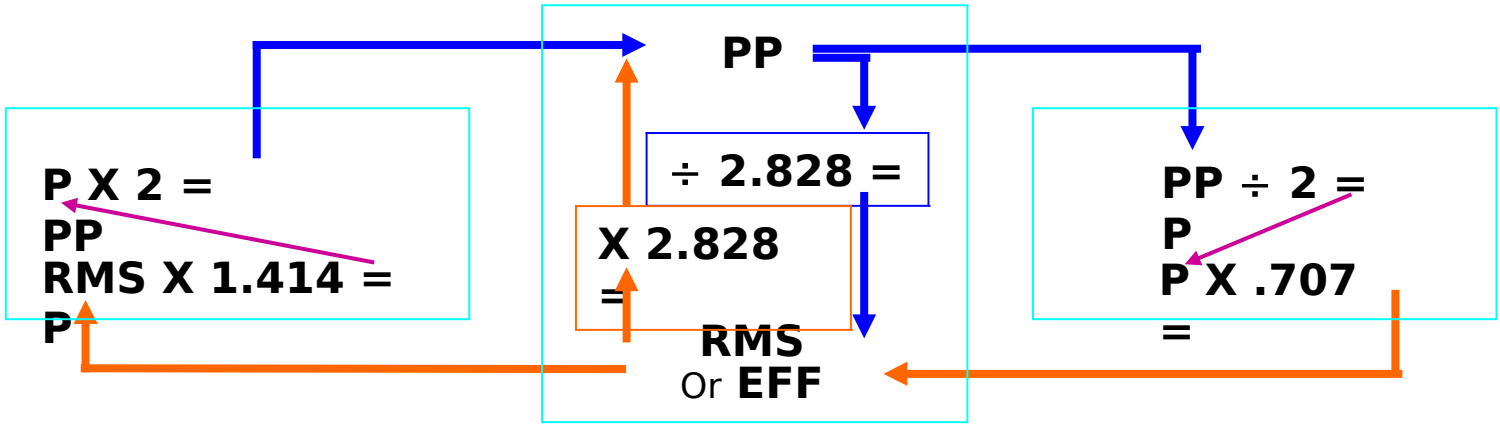
P X .707 = RMS or **EFF**

PP ÷ 2.828 = RMS

RMS X 1.414 = P

RMS X 2.828 = PP

P X 2 = PP



AC: Intro To AC & Freq;

Equivalent Values; Voltages Conversions & Phase.

You went to buy a new Stereo System, the salesman showed a system that put out "200 Watts", of course the salesman doesn't know what you know, he gives you the power that will make the most impressive sale.

So what are you really getting? [pp value is given.]

Watts Peak____?

PP ÷ 2 = P

P X .707 = RMS or EFF

RMS X 1.414 = P

P X 2 = PP

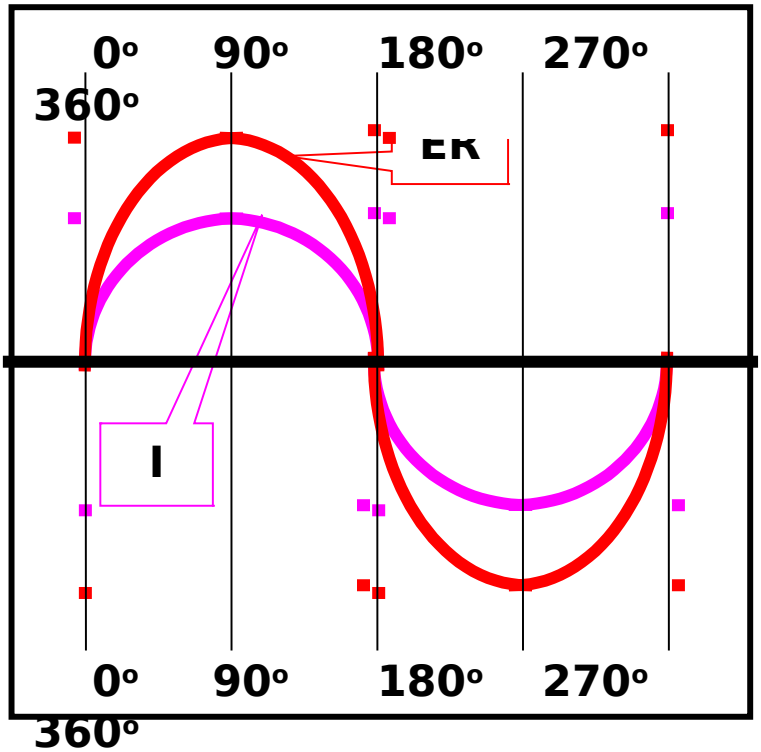
Watts RMS ____?

PP ÷ 2.828 = RMS

RMS X 2.828 = PP

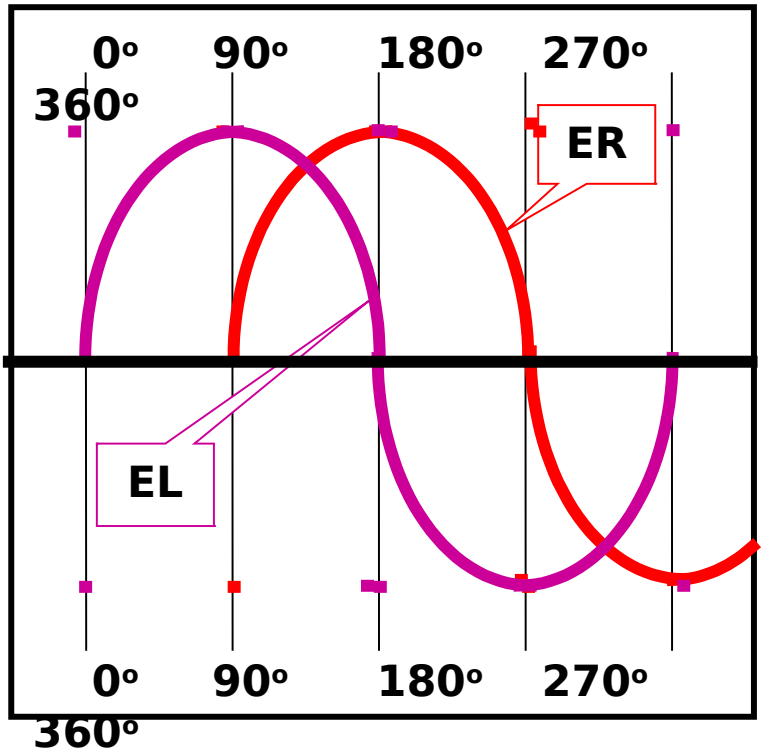
Phase Relationships;

IN Phase; Sine



Voltage across a Resistor & Current are IN Phase.

OUT of Phase; Sine

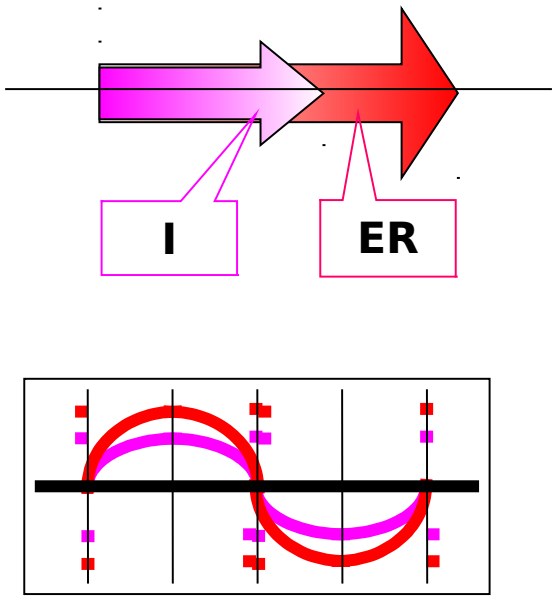


The EL is Leading the Voltage across a Resistor by 90º.

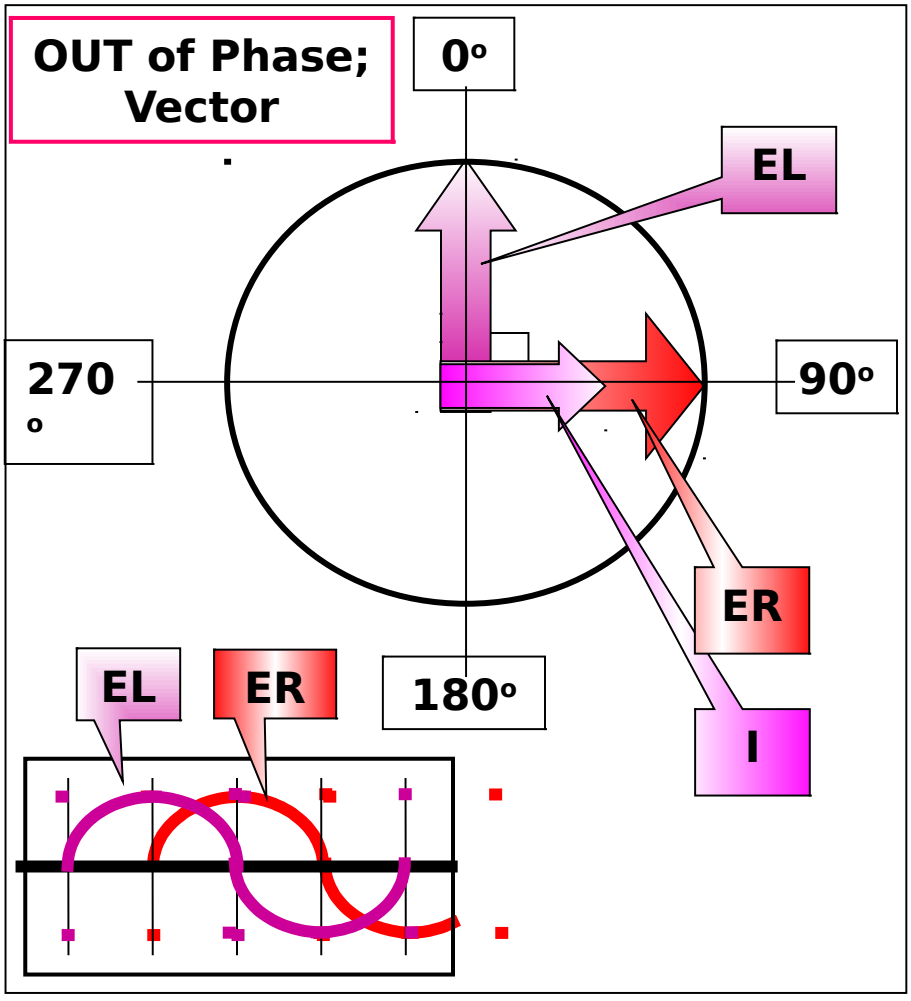
Or the ER is Lagging the EL by 90º.

Phase

IN Phase; Vector



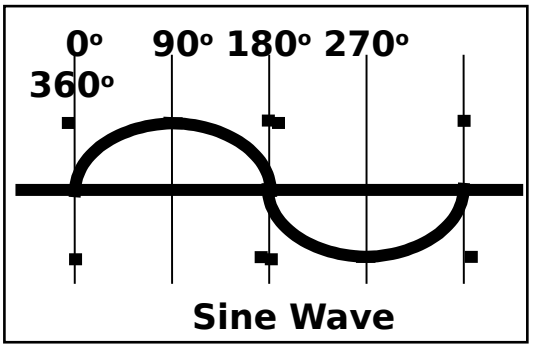
OUT of Phase; Vector

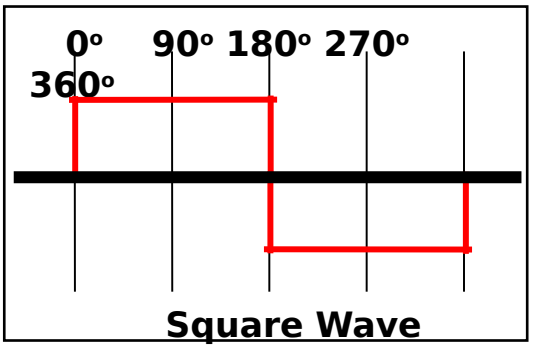


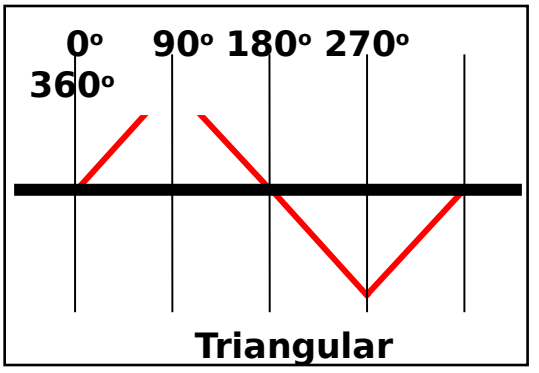
When reading a Vector, read counterclockwise, the entity that reaches the 12:00 position 1st, is leading.

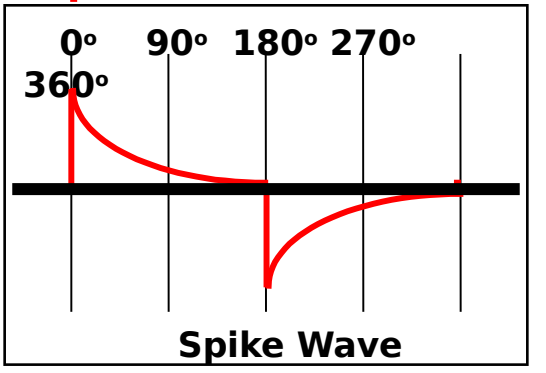
AC: Intro To AC & Freq;

Waveforms; Outside of the Sinewave, waveforms fall into 3 basic types. All Calculations, Period & Frequency and Voltages are calculated the very same.









Calculate; Determine from the illustration the information given, and calculate the required unknowns.

PW = _____ ?

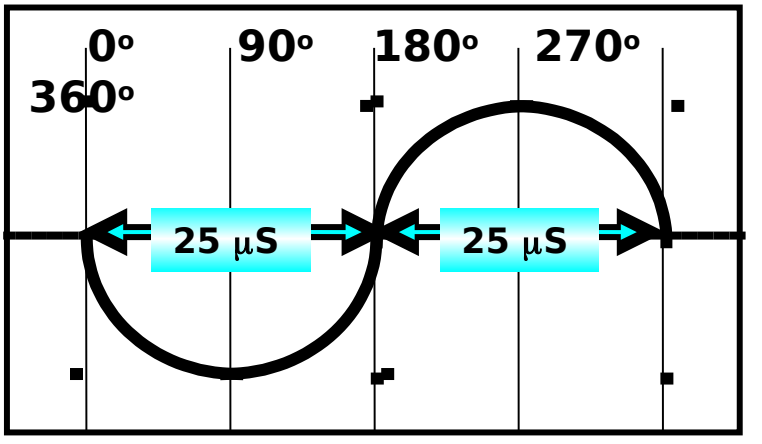
Period = _____ ?

Freq = _____ ?

PW = 25 μS

Period = 2 X PW

Freq = P 1/X



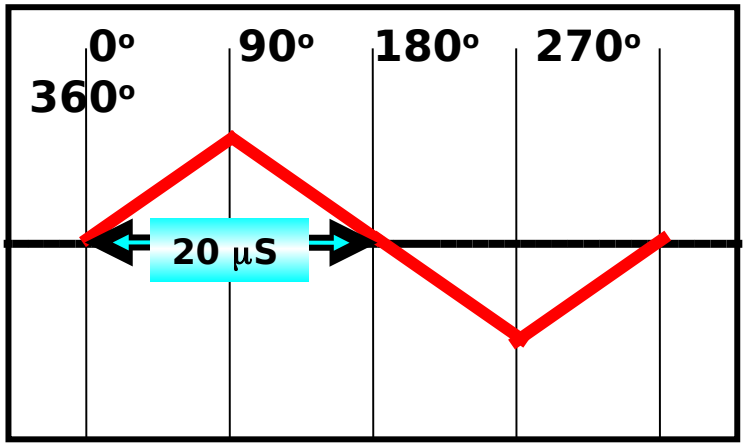
Note:

If there is μS in the Period, there will be KHz in the Frequency.

50 EE -6 1/X ⇒ 20000. = 20 KHz

Freq & Period Calculations;

Determine from the illustration the information given, then calculate the required unknowns.

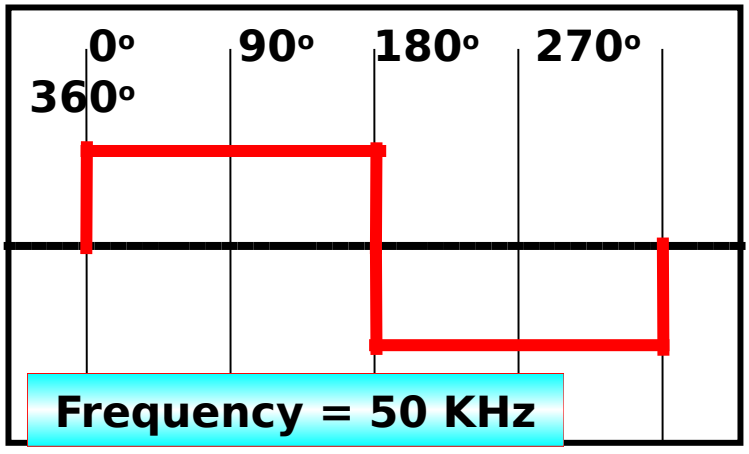


PW = _____ ?

Period = _____ ?

Freq = _____ ?

P EE -6 1/X ⇒ Freq in KHz

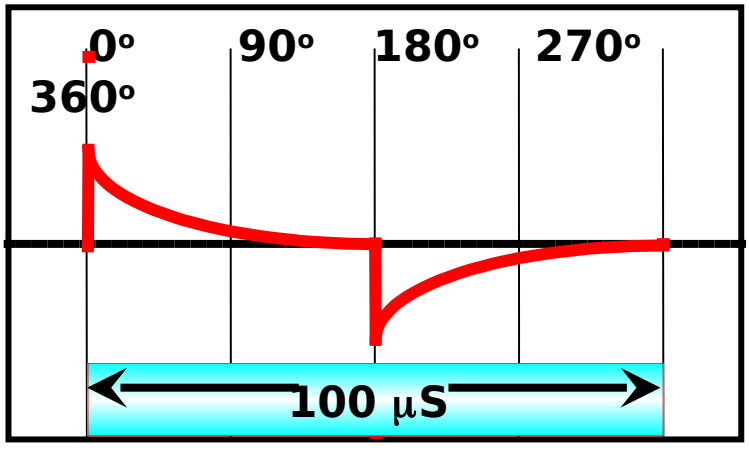


Freq = _____ ?

Period = _____ ?

PW = _____ ?

Freq EE 3 1/X ⇒ P in μS



Freq = _____ ?

Period = _____ ?

PW = _____ ?

Freq = P 1/X

Period = Freq 1/X

PW = ½ P

Period = 2 X PW

Note:

If there is KHz in the Frequency, there will be μS in the Period.

Note:

If there is μS in the Period, there will be KHz in the Frequency.

AC: Intro To AC & Freq;

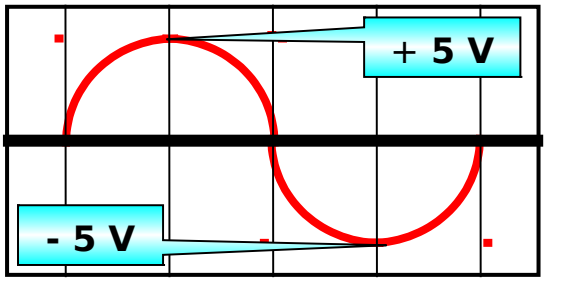
Problem Sheets; Fill in the blanks.

1. What are the magnetic lines of force of a magnet called? _____

2. What is the Law of Magnets ? _____

3. How many degrees are there in an AC Alternation ? _____

4. What is the peak Voltage of the waveform ? _____



5. What is the peak to peak Voltage of the waveform ? _____

6. How many alternations are there in a complete AC waveform ? ___

7. When using the Left Hand Rule, what property is represented by the thumb ? _____

8. Which of the three types of magnets will be magnetized during the time that Current is flowing through the conductor wrapped around a core ? _____

9. The Effective Voltage is 20V. What is the Peak Voltage ? _____

10. The Peak Voltage is 50 V. What is its RMS Voltage ? _____

11. The Peak to Peak Voltage is 60V. What is its Effective voltage ? _____

12. The RMS Voltage is 15 V. What is the Peak to Peak Voltage ? _____

13. The Alternation below the 0V reference line is called the _____ alternation.

14. The Peak Voltage of a waveform is 10 V. The Peak to Peak Voltage is _____

PP ÷ 2 = P

P X .707 = RMS or EFF

RMS X 1.414 = P

PP ÷ 2.828 = RMS

RMS X 2.828 = PP

P X 2 = PP

Problem Sheets; Fill in the blanks.

15. The RMS Voltage is 5 V, what is the Peak Voltage ? _____

16. The Peak Voltage is 20V, what is the RMS Voltage ? _____

17. The RMS is 7 V, what is the Peak to Peak ? _____

Problem Sheets; Frequency Calculations

1. Period = 5 m Sec	Frequency = _____
2. Period = _____	Frequency = 100 KHz
3. Period = 40 μ Sec	Frequency = _____
4. Period = _____	Frequency = 20 Hz
5. Period = 80 μ Sec	Frequency = _____
6. Period = _____	Frequency = 50 Hz
7. Period = 50 μ Sec	Frequency = _____
8. Period = _____	Frequency = 25 Hz

μ Sec	⇄	KHz
m Sec	▯	Hz

Continued Next Page

AC: Intro To AC & Freq;

Problem Sheets: Frequency Calculations

9. Period = 100 m Sec — Frequency = _____

10. Period = _____ — Frequency = 4 KHz

11. Period = 15 μ Sec — Frequency = _____

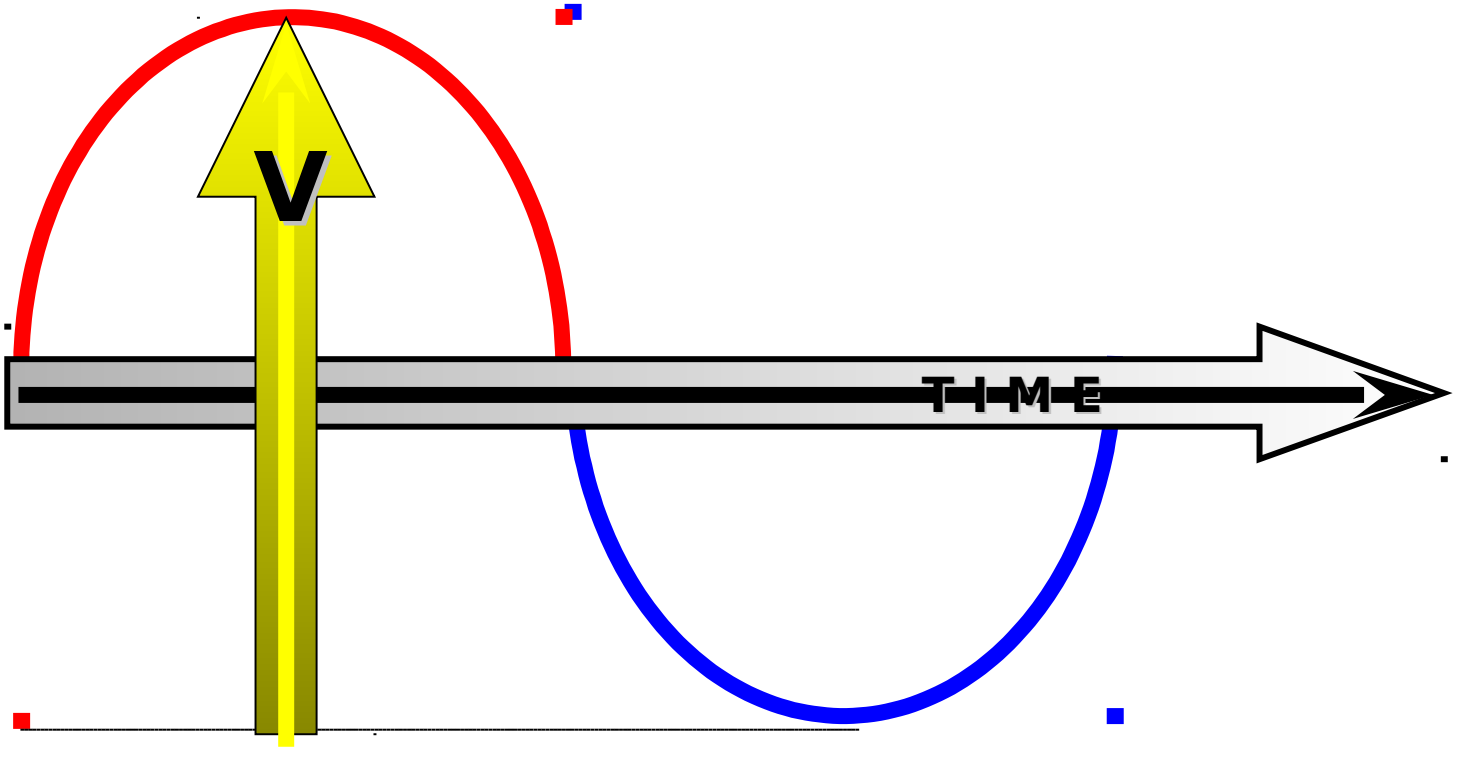
12. Period = _____ — Frequency = 8 KHz

13. Period = 60 m Sec — Frequency = _____

14. Period = _____ — Frequency = 30 Hz

15. Period = 25 μ Sec — Frequency = _____

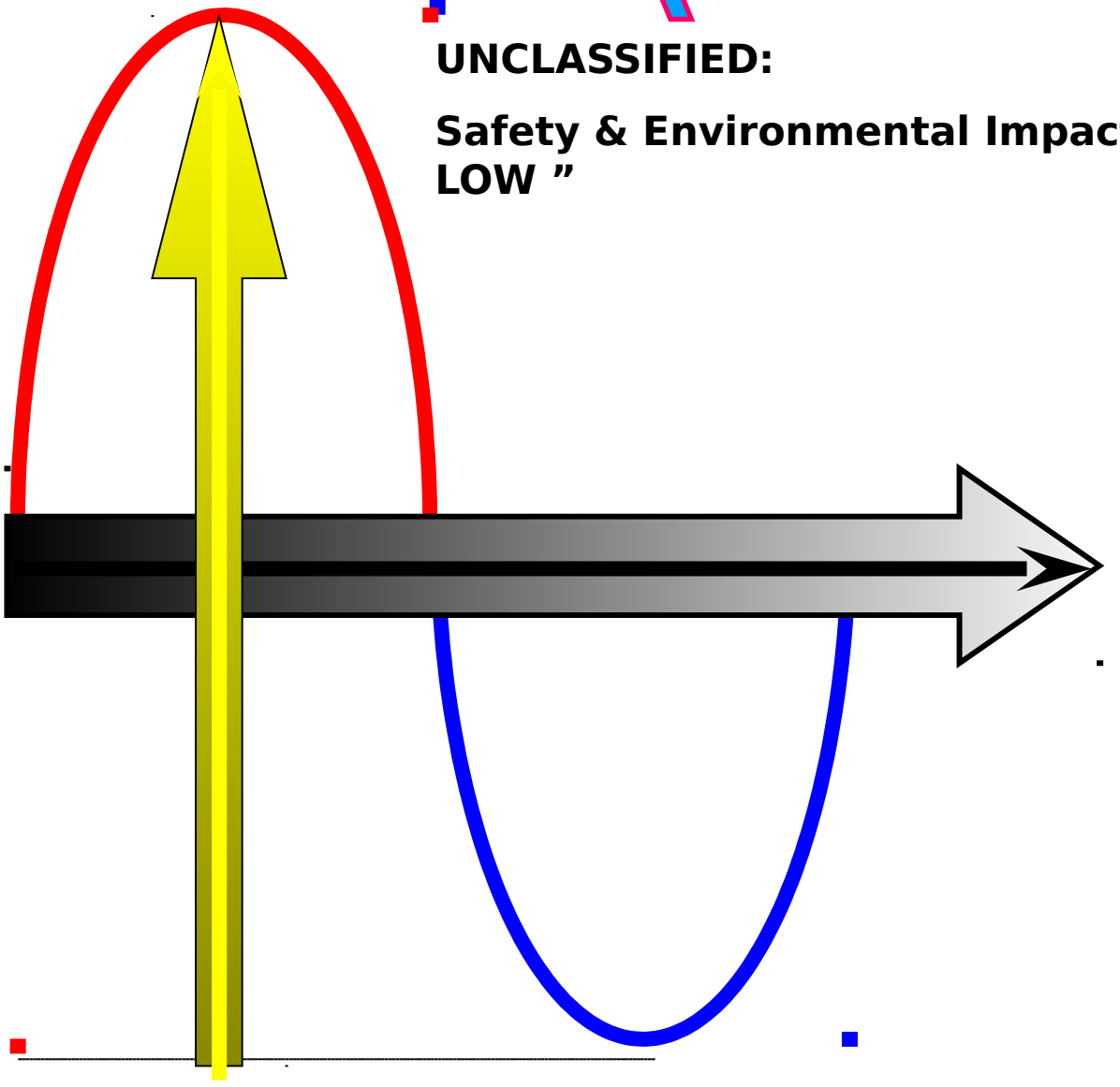
μ Sec	□	KHz
m Sec	□	Hz



AC TEST EQUIPMENT

UNCLASSIFIED:

Safety & Environmental Impact: “ LOW ”

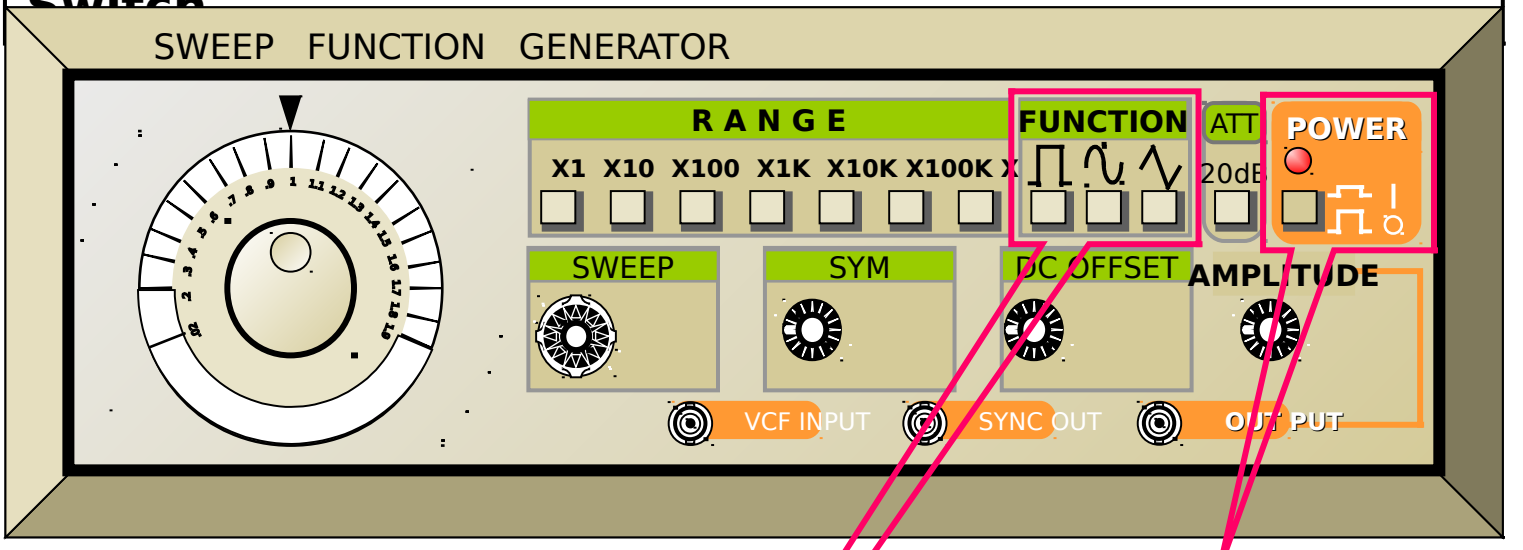


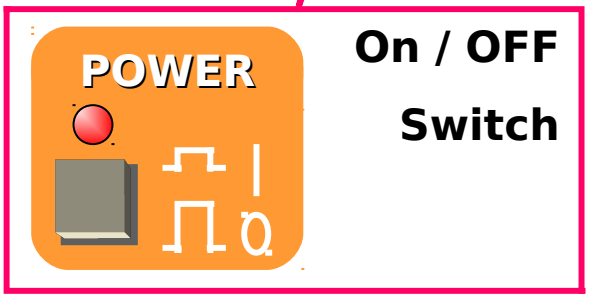
Given a function Generator & Oscilloscope, set-up & measure for Voltage, Period, Pulse Width & calculate for Frequency.

With New Function Generator/ Old function generator is retained.

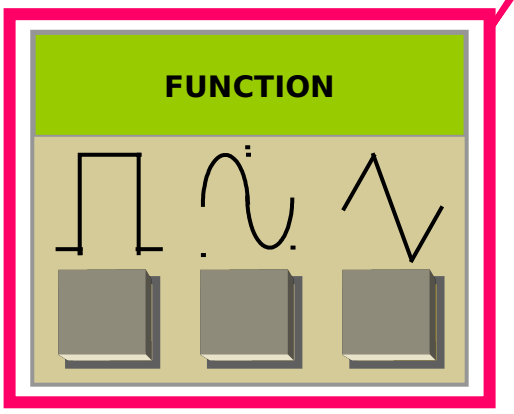
AC: Test Equipment. NEW Function Generator.

Function Generator; Power Switch, & Function Switch



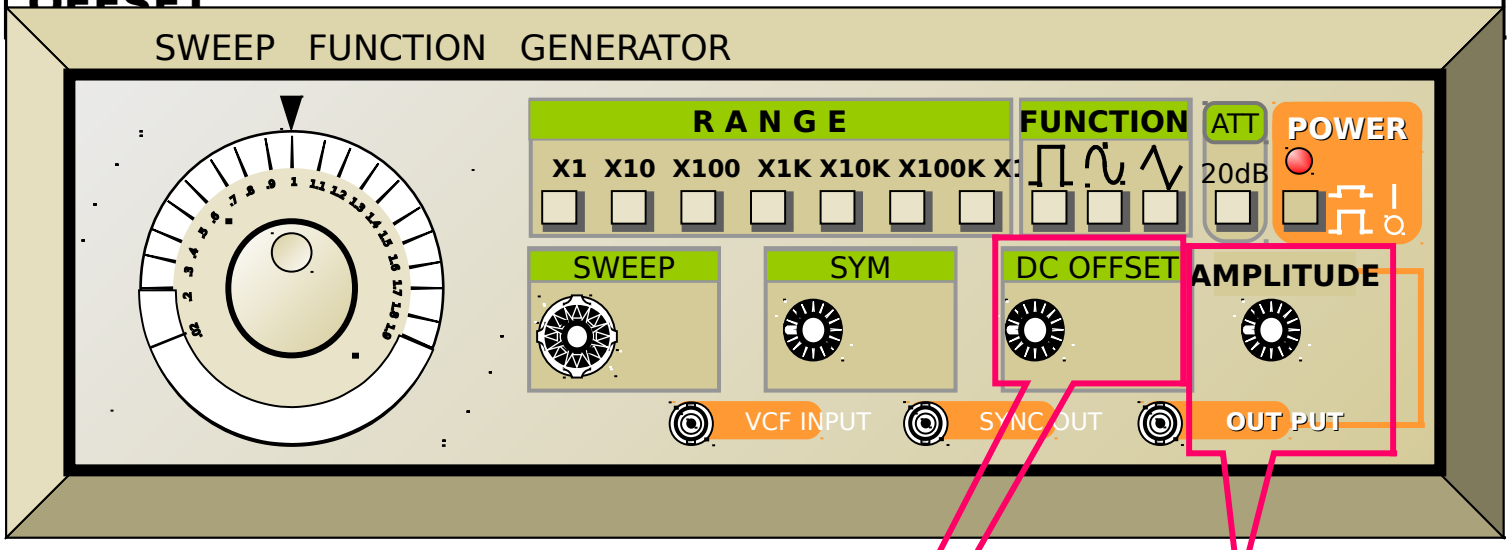


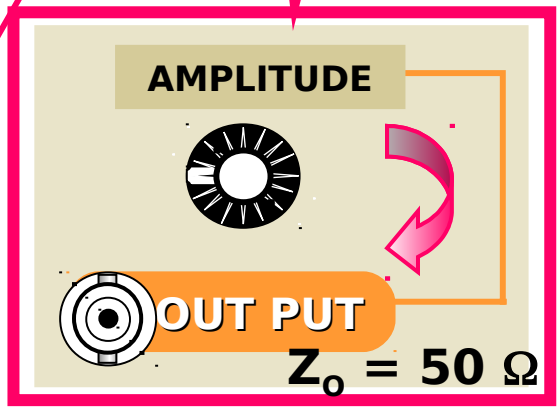
Function Switch.



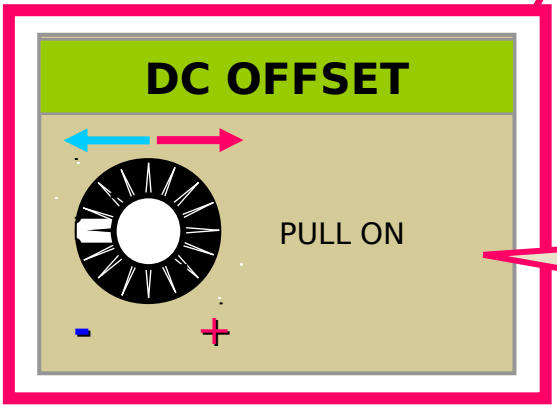
AC: Test Equipment. NEW Function Generator.

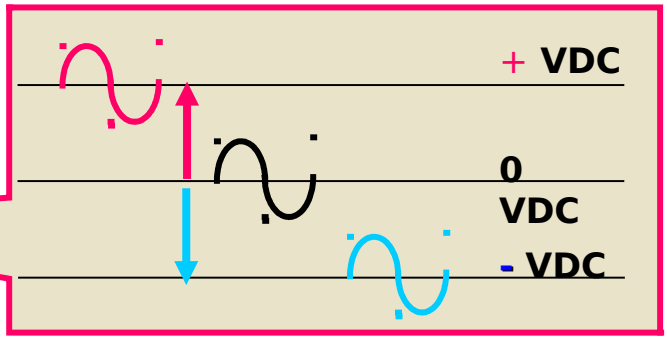
Function Generator; AMPLITUDE CONTROL KNOB & DC OFFSET





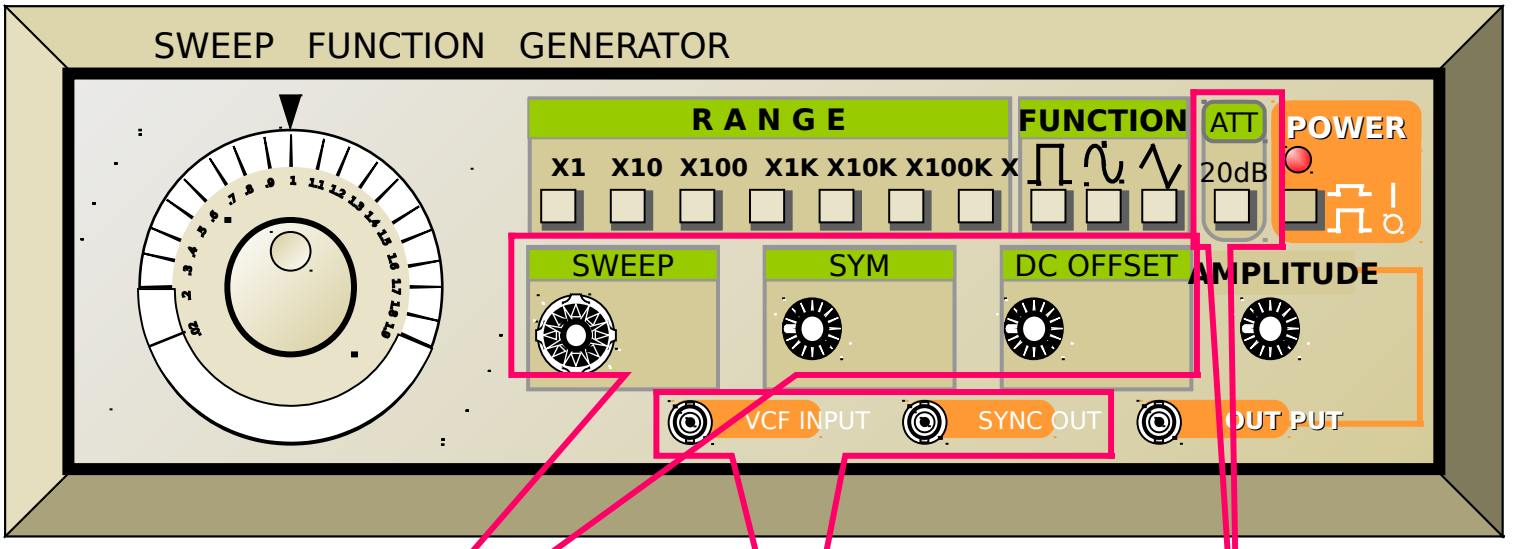
DC OFFSET.

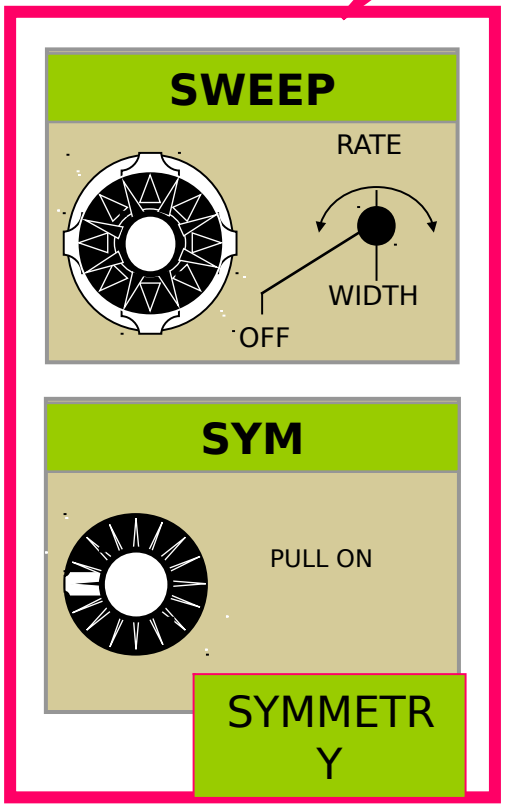


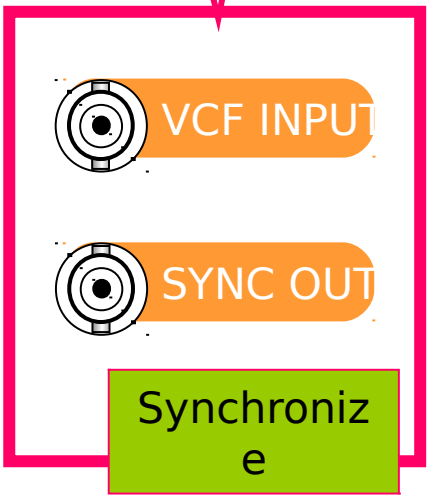


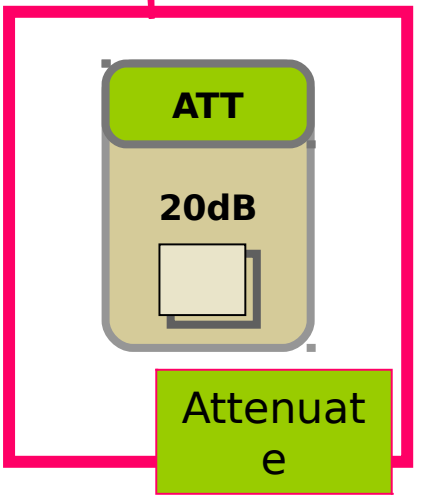
AC: Test Equipment. NEW Function Generator.

Function Generator; SWEEP, SYM & ATT





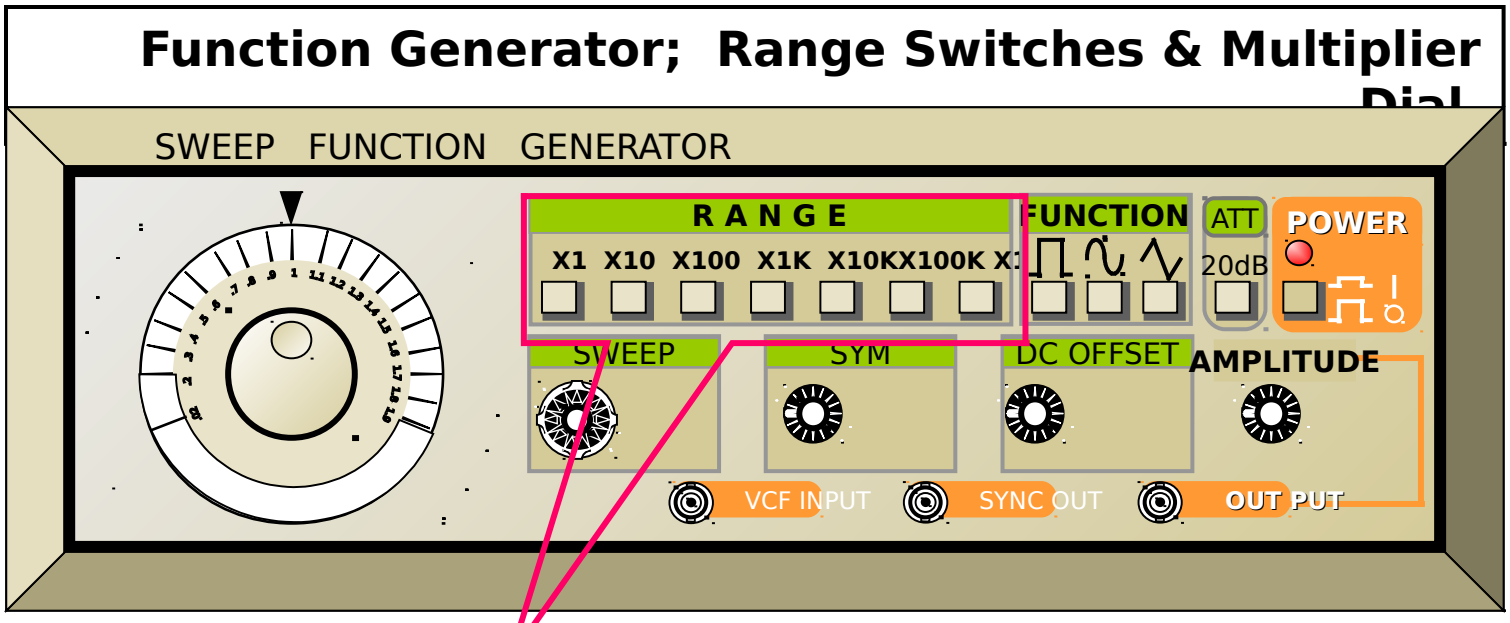


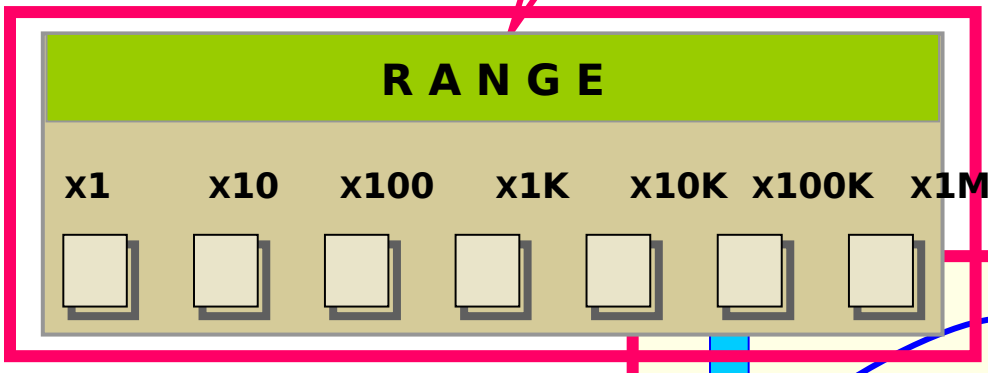


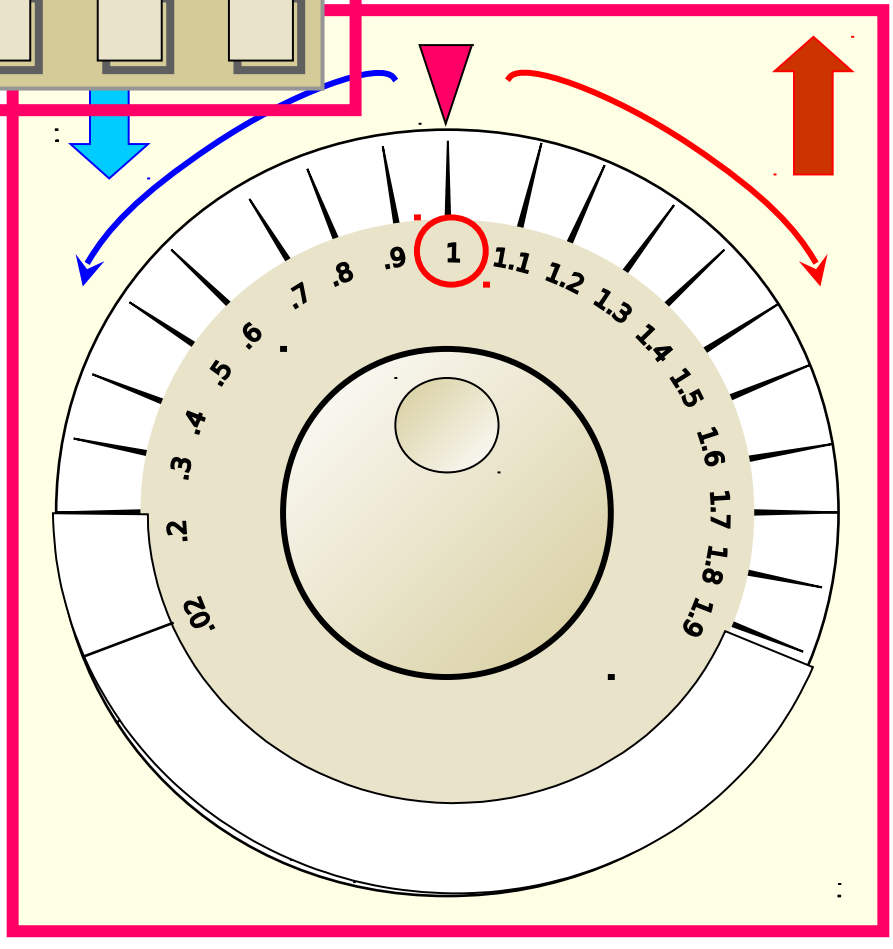
These Functions will not be used in the classroom.

AC: Test Equipment. NEW Function Generator.

Function Generator; Range Switches & Multiplier Dial

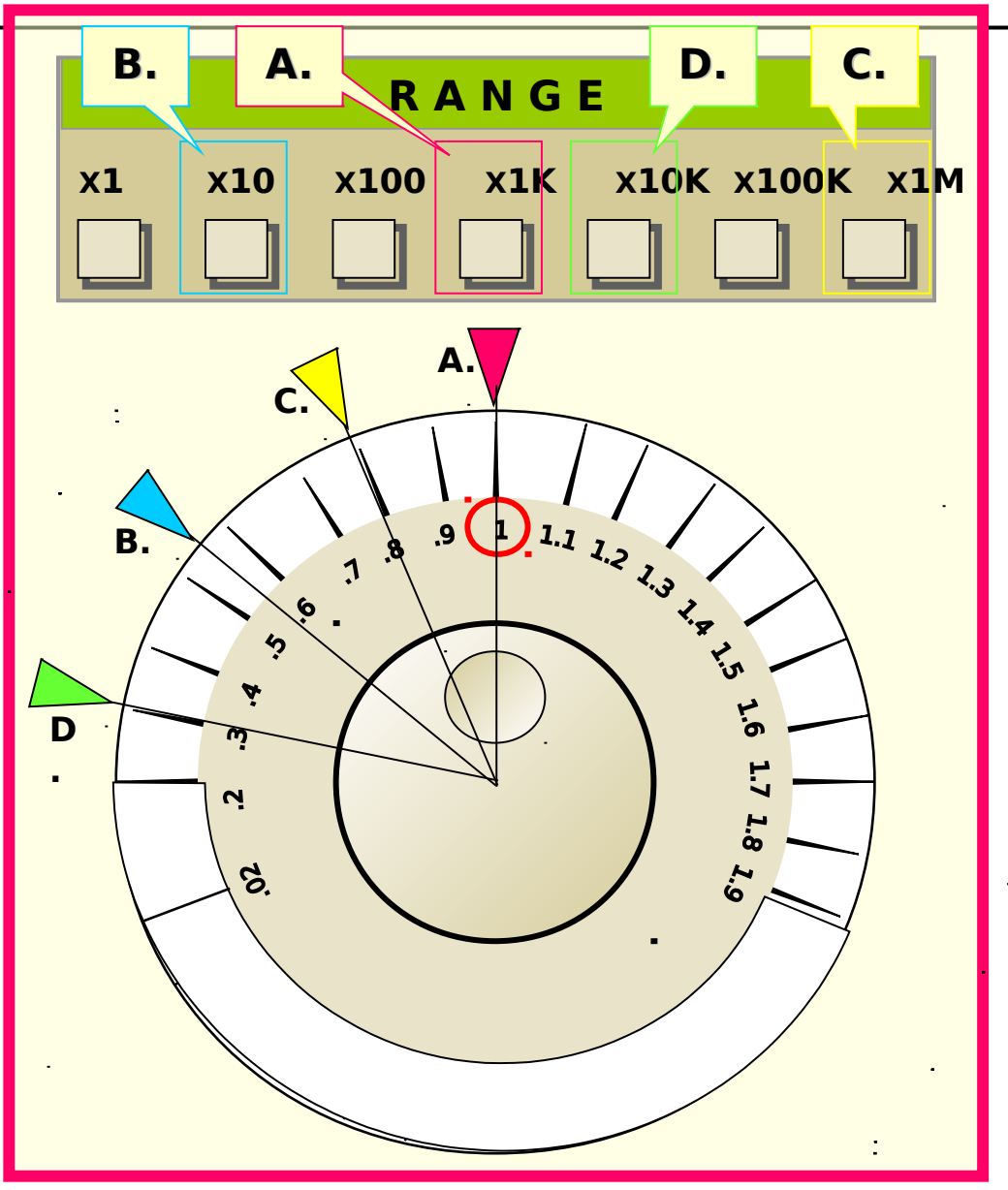






AC: Test Equipment. NEW Function Generator.

What is the output Freq ? Reference the Range Sw & Dial position.



A. [Range **1K**] X [Dial **1**] =

A. Frequency = 1 KHz

B. Frequency = _____

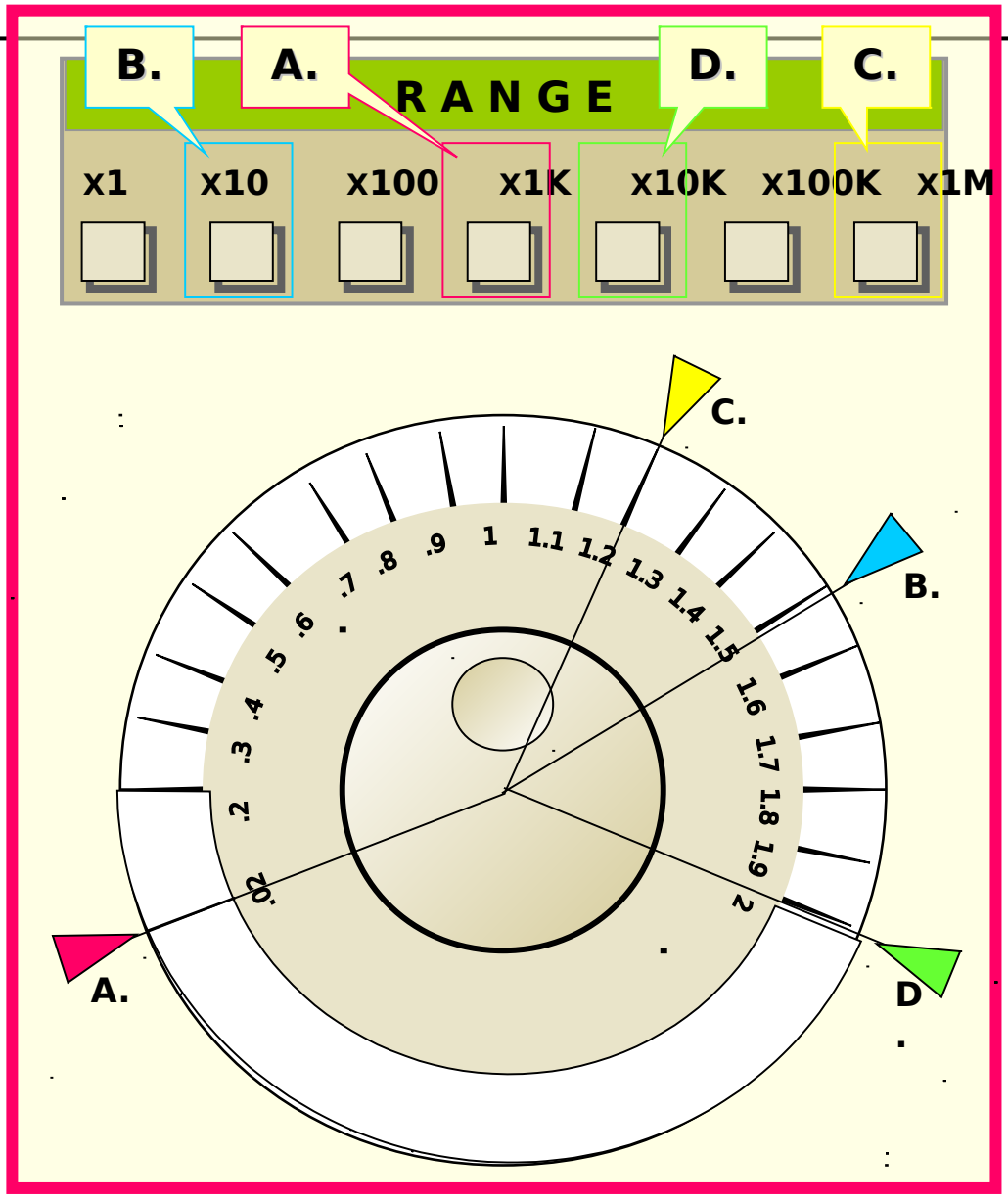
C. Frequency = _____

D. Frequency = _____

E. The Range is **x**1K. Rotating the Multiplier Dial clockwise from the reference mark of 1, Increases / Decreases the frequency on the output **.**

AC: Test Equipment. NEW Function Generator.

What is the output Freq ? Reference the Range Sw & Dial position.



A. **Frequency = _____**

B. **Frequency = _____**

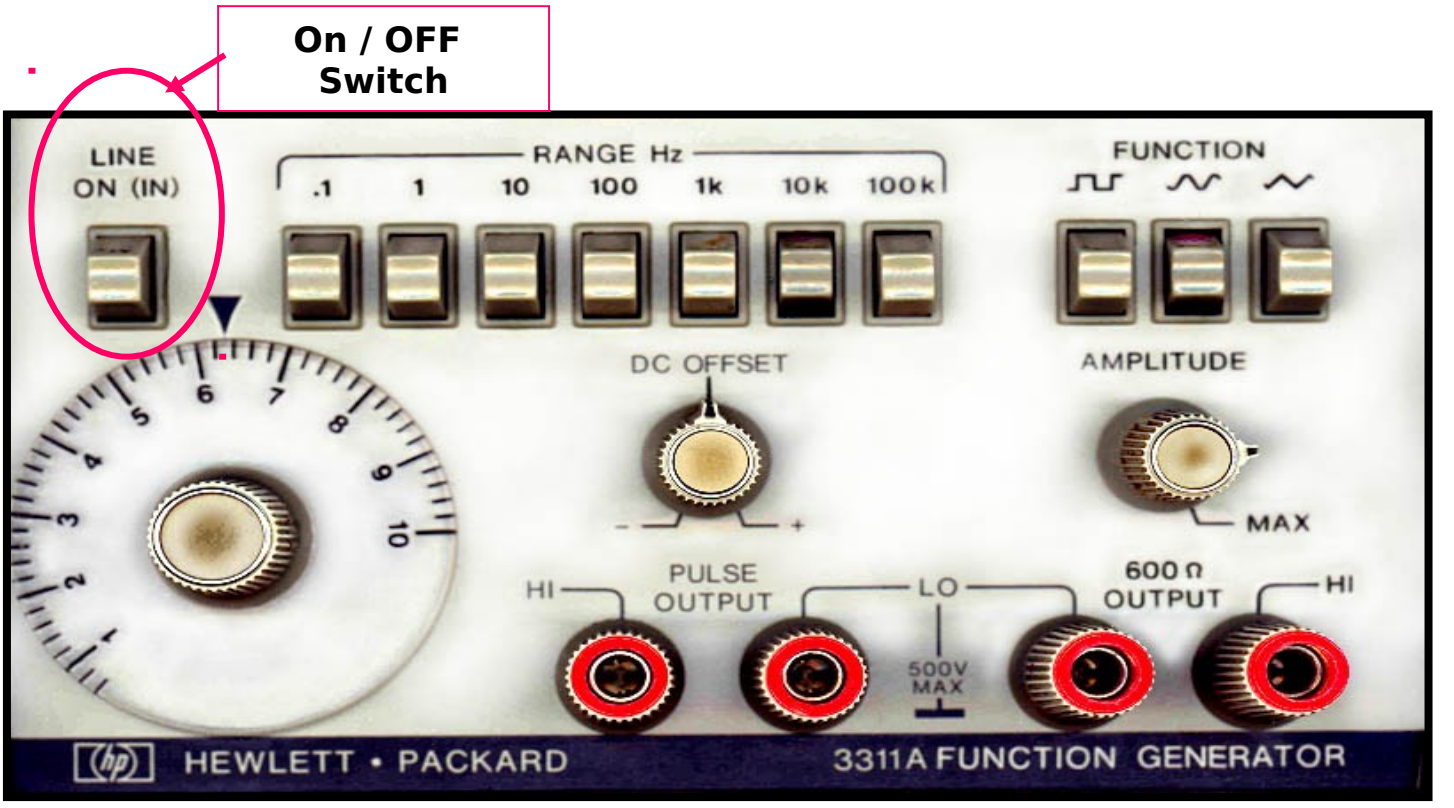
C. **Frequency = _____**

D. **Frequency = _____**

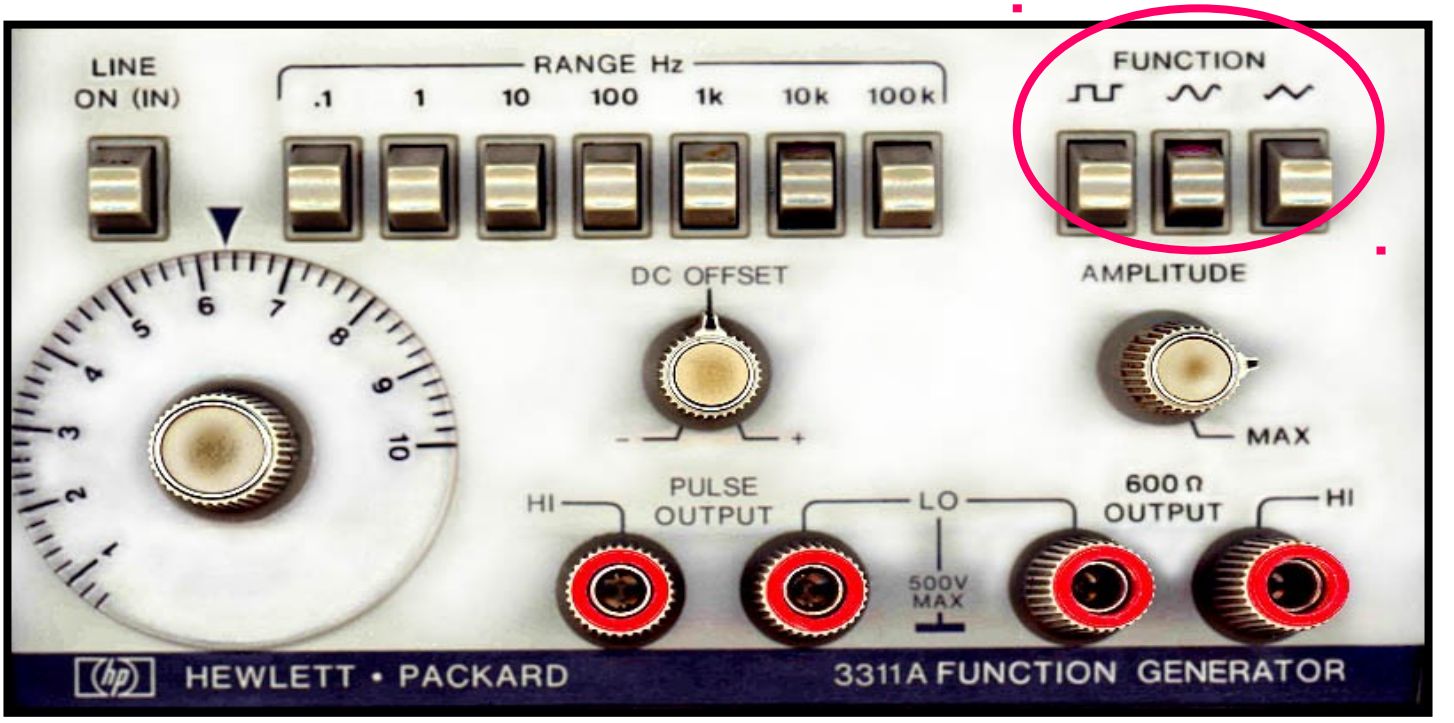
E. The Range is **x**1K. Rotating the Multiplier Dial counterclockwise from the reference mark of 1, Increases / Decreases the frequency on the output .

AC: Test Equipment

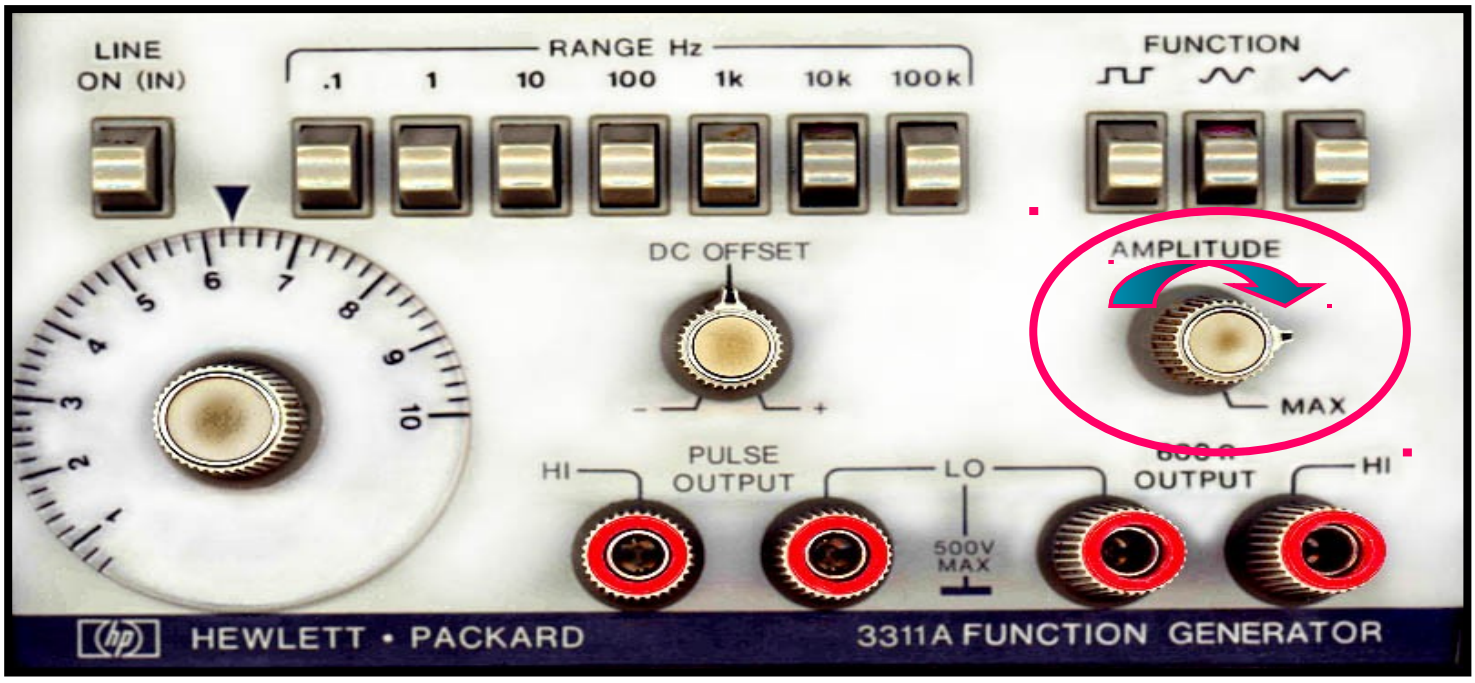
Function Generator; Line Switch.



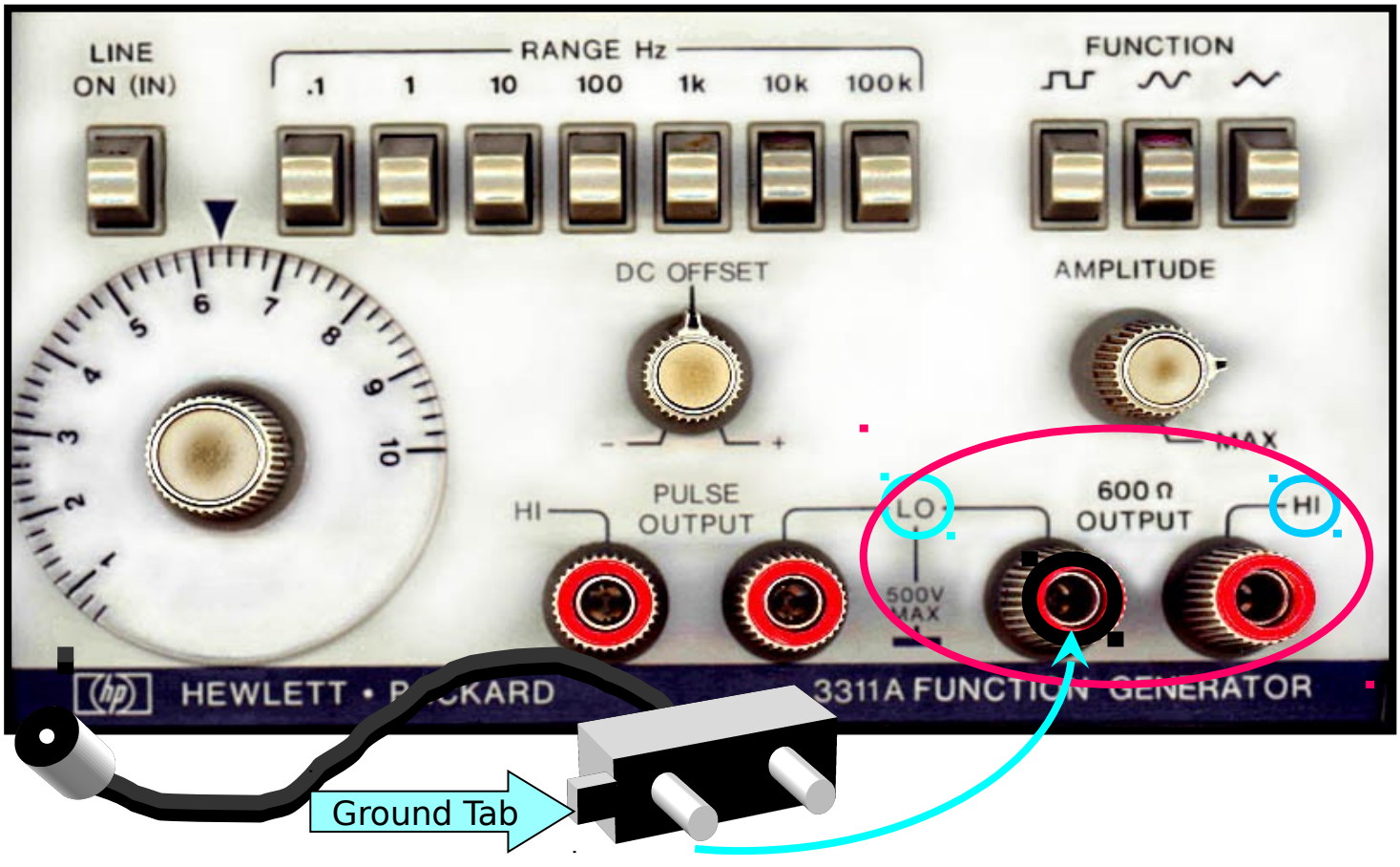
Function Switch.



Function Generator; Amplitude Knob.



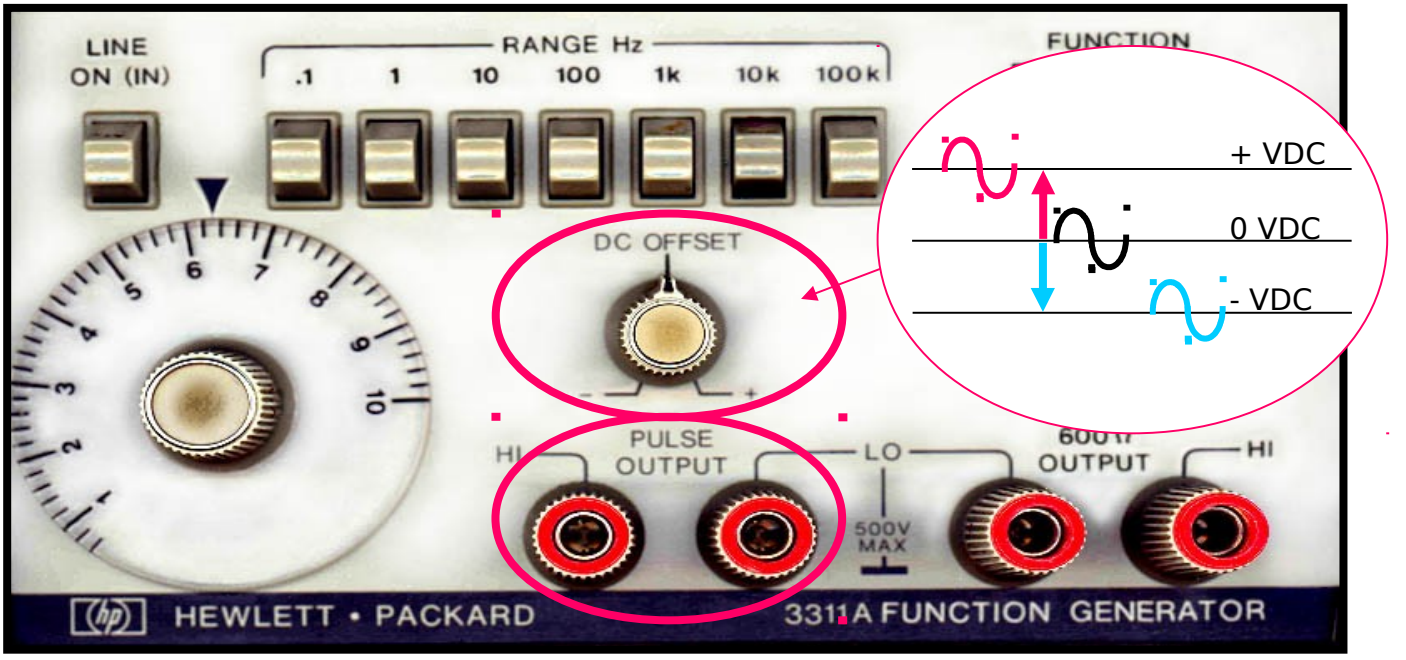
Output Jack.



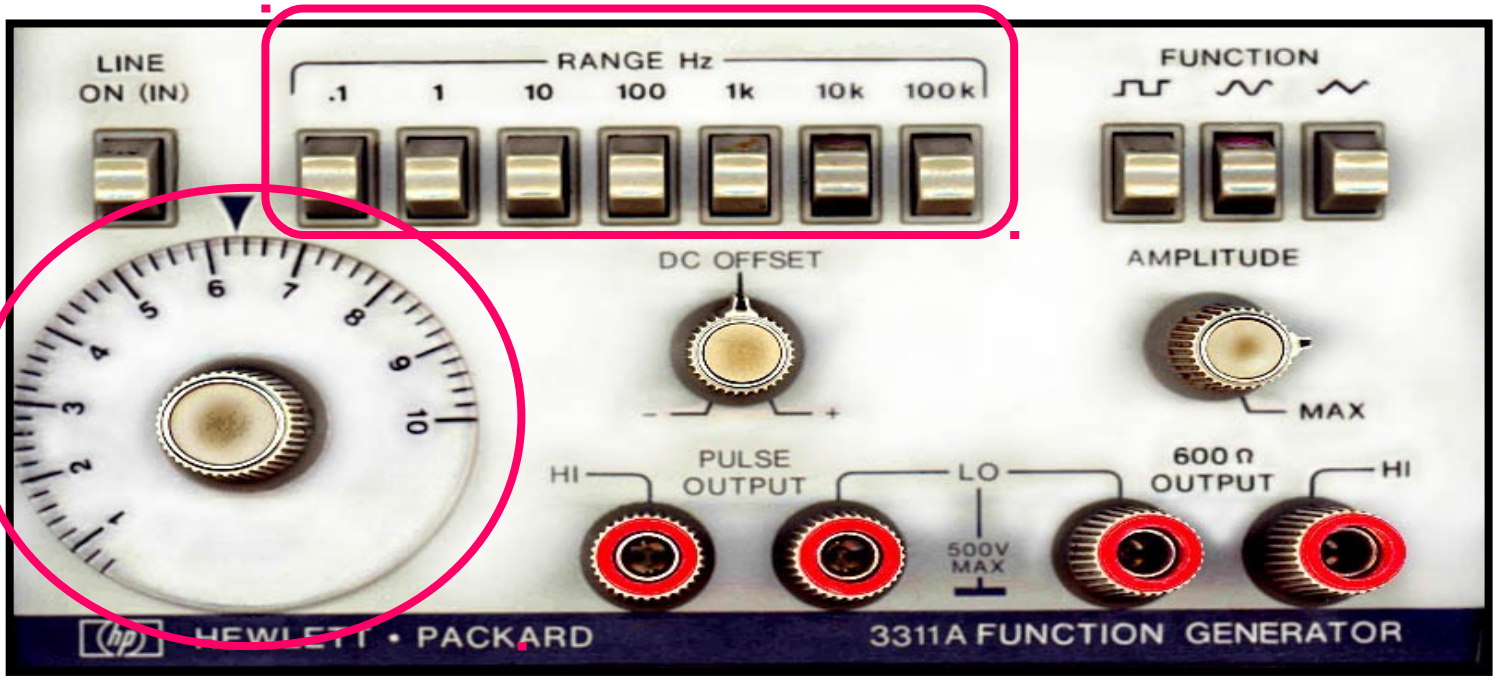
AC: Test Equipment

Function Generator;

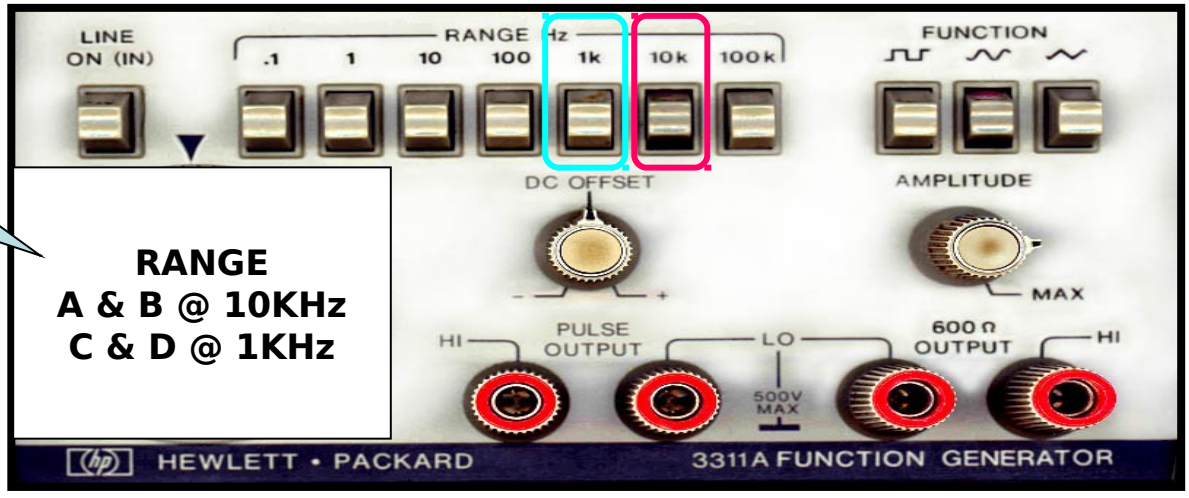
DC Offset & Pulse Output. [Not used in the classroom]



Multiplier Dial.

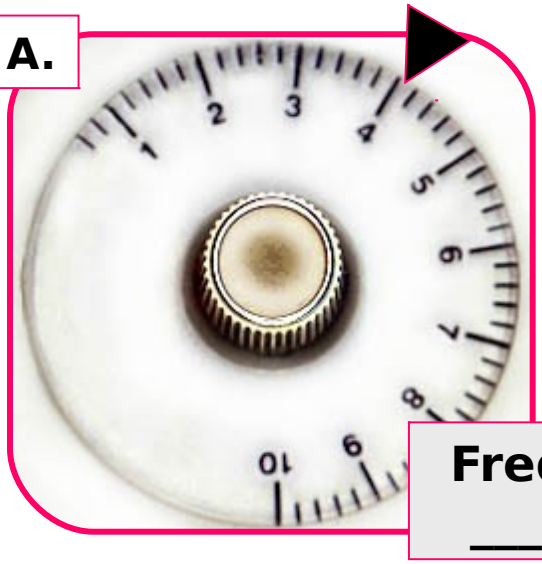


Function Generator; Multiplier Dial. What is the output Freq, Reference the Range Sw & Dial position as illustrated.



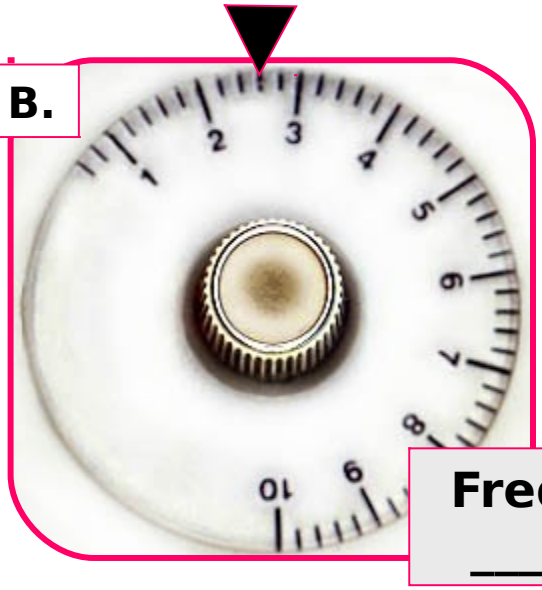
RANGE
A & B @ 10KHz
C & D @ 1KHz

A.



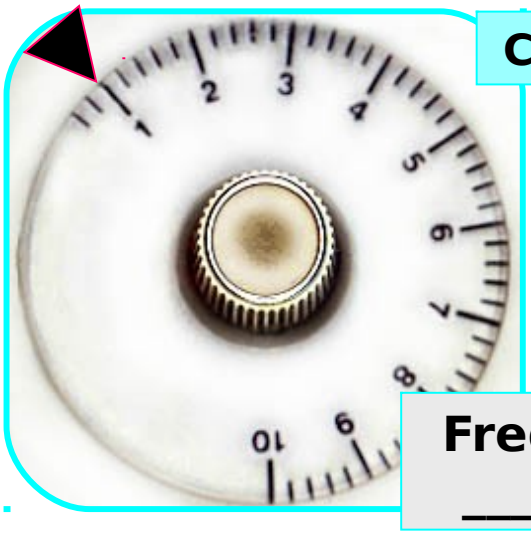
Freq= _____

B.



Freq= _____

C.



Freq= _____

D.

Freq= _____

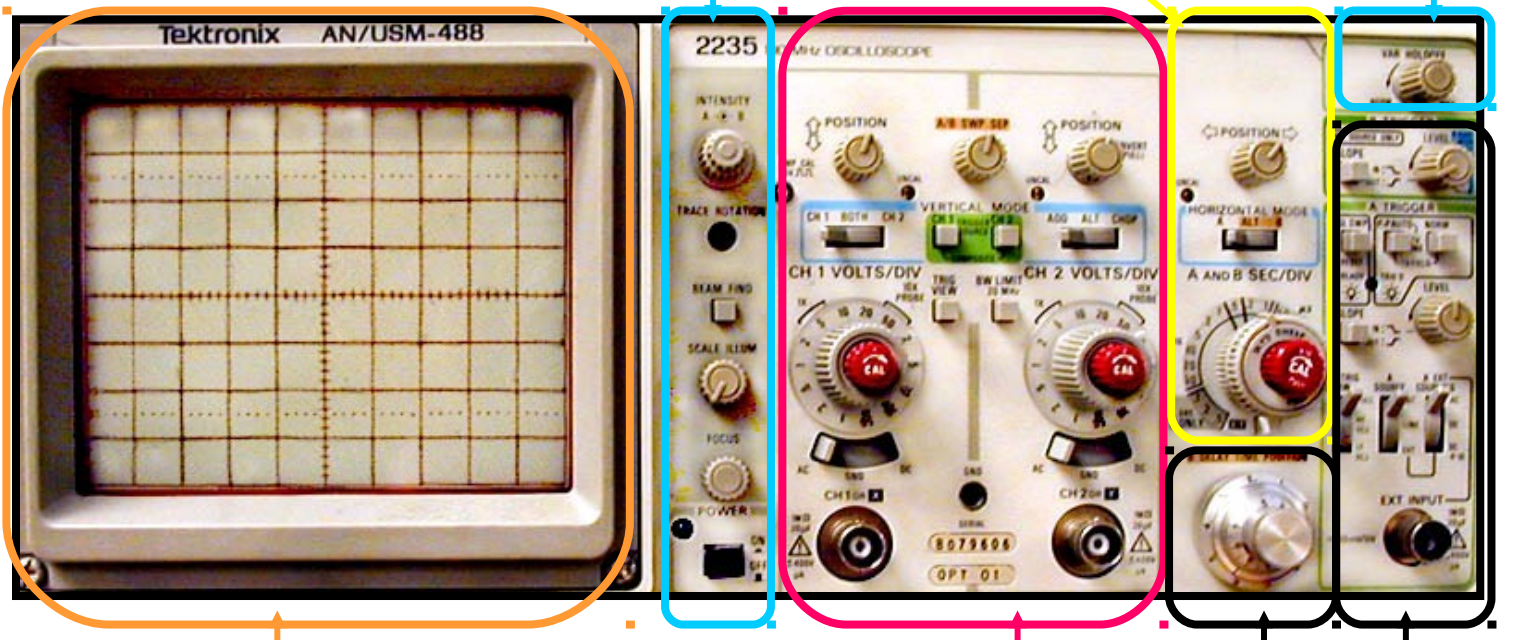
AC: Test Equipment

Oscilloscope; Breakdown & ID the Basic Functional Zones.

Display Controls
Power, Focus, Scale Illum,
Beam Find, Intensity

SEC / DIV
W/ Left to right
signal Positioning

Var
Display Stabilization

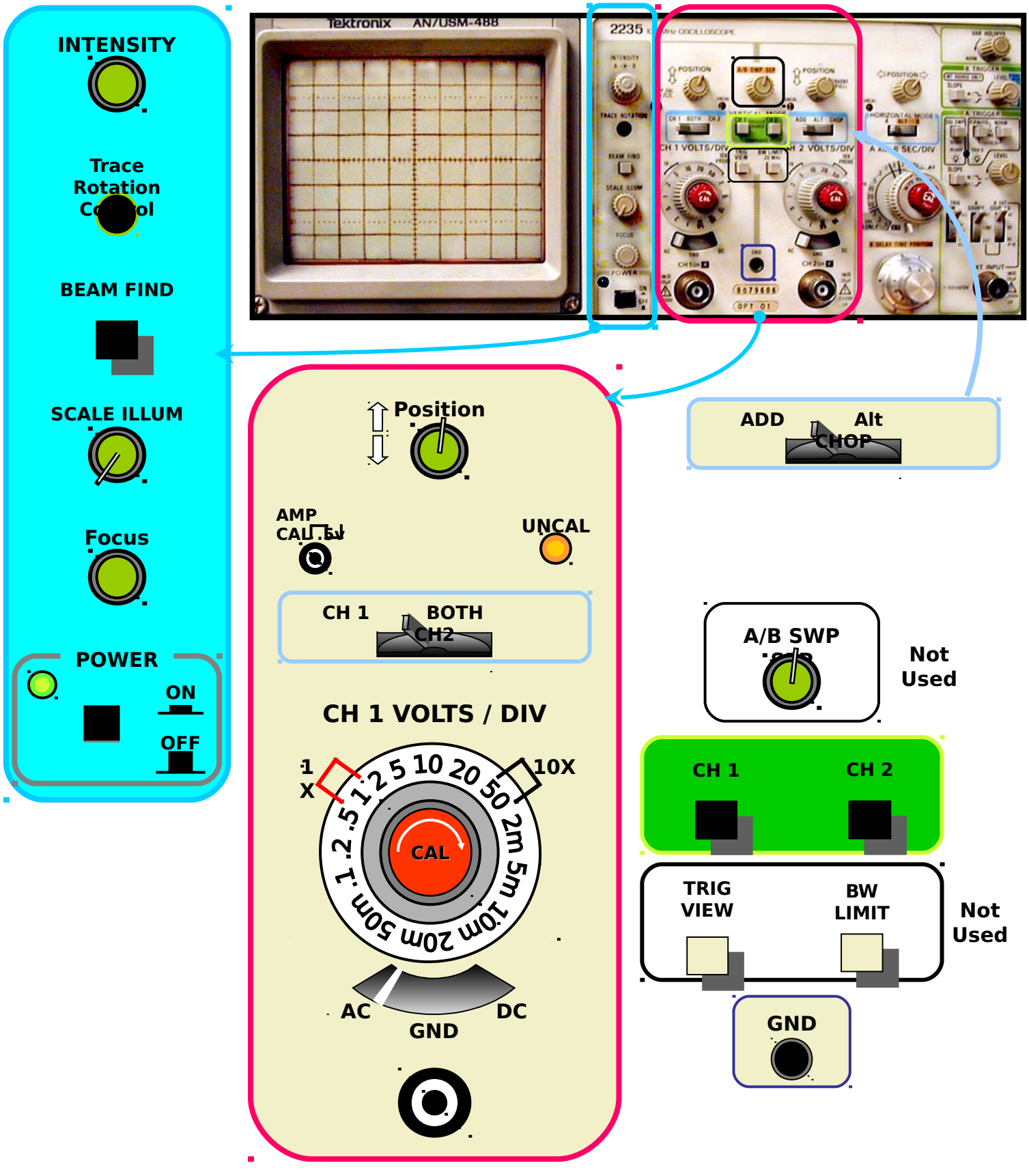


Display CRT
W/ Major & Minor Graticule

VOLTS / DIV
2 Channels
W/Up & Down signal Positioning

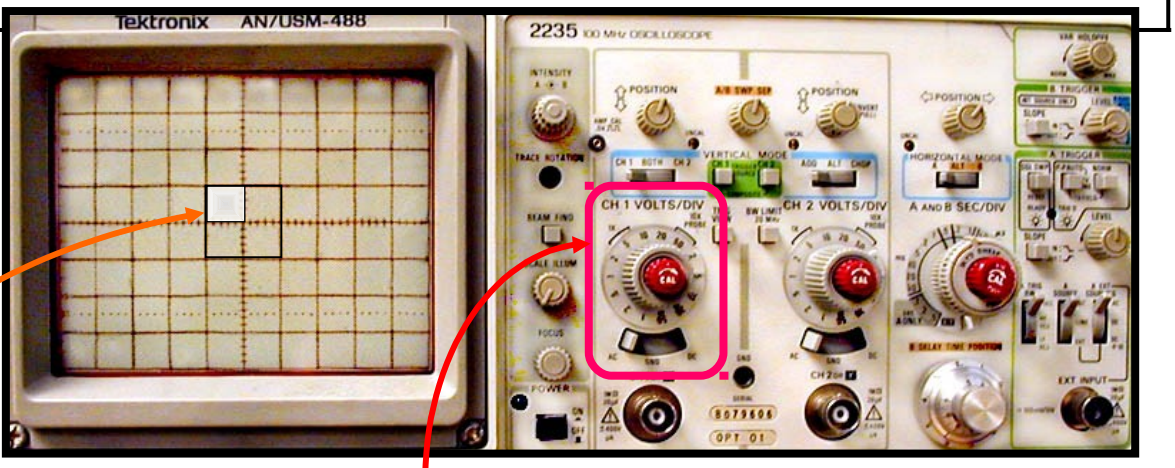
Not used
in classroom

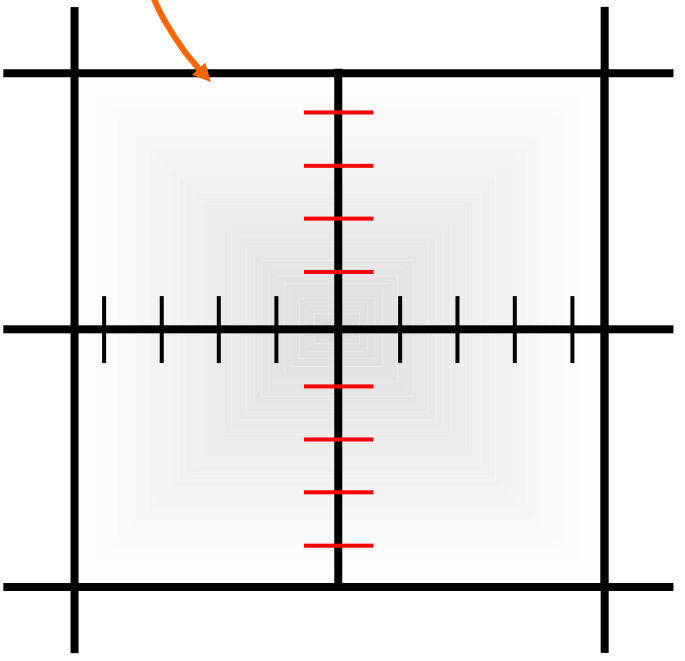
Oscilloscope; Display Controls & Volts/Div.

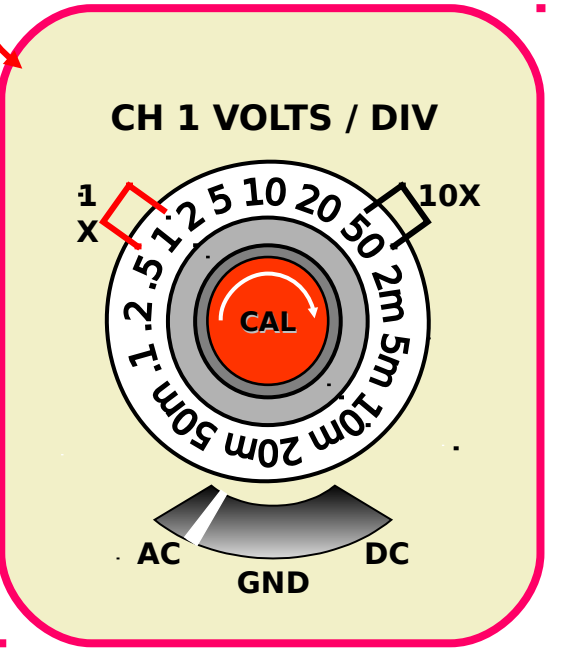


AC: Test Equipment

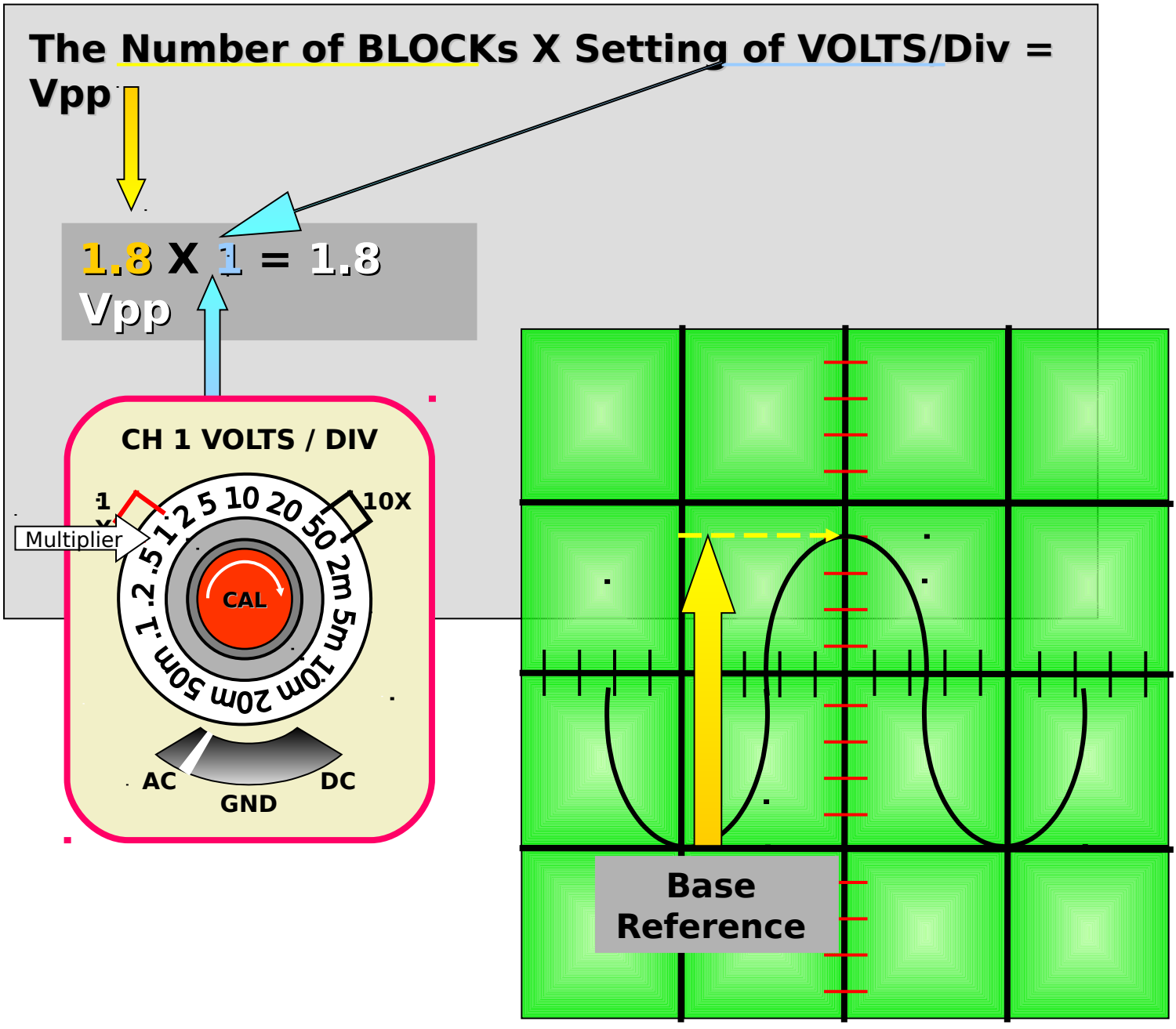
Oscilloscope; Determine the Value of Volts Per Division.





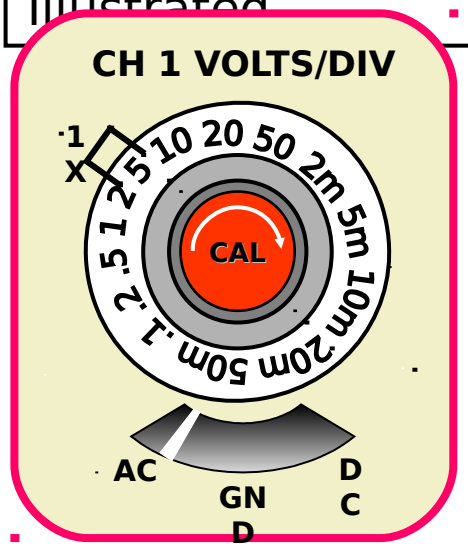


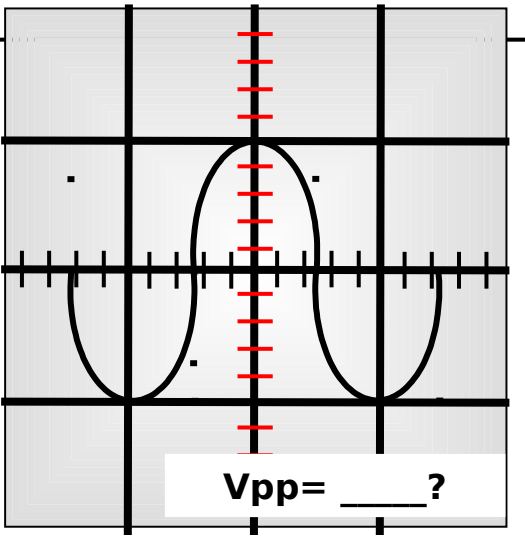
Oscilloscope; Calculating the Voltage of a signal.

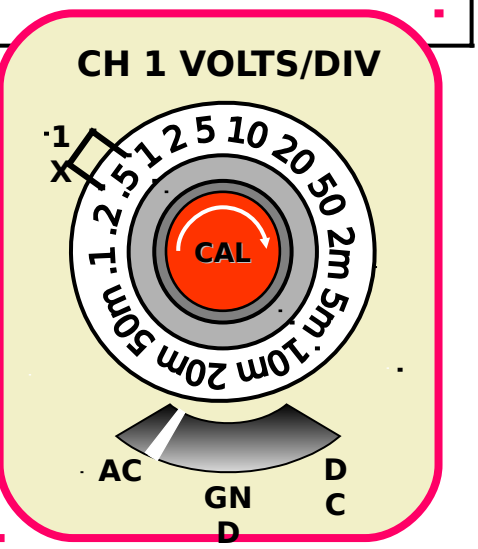


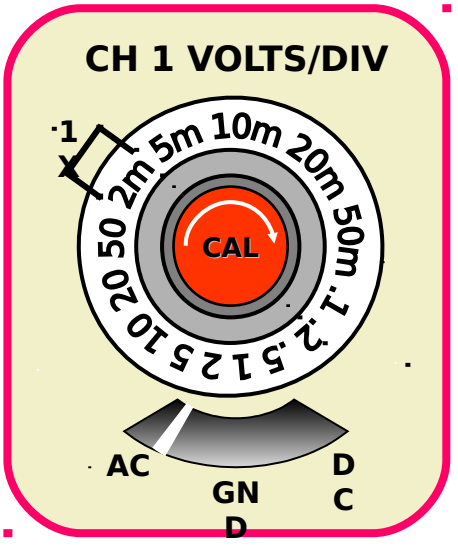
AC: Test Equipment

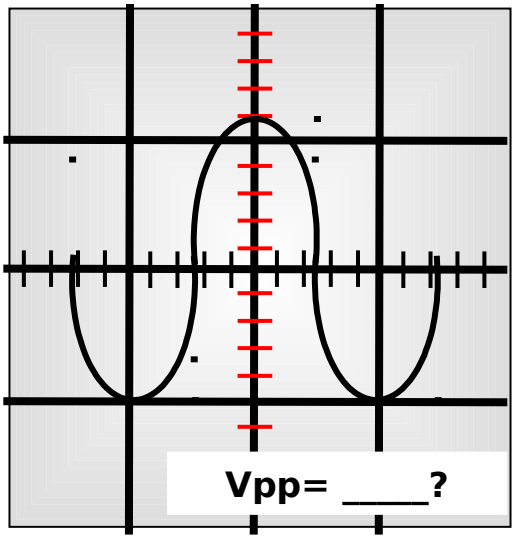
Oscilloscope; <u>Calculate</u> the Voltage of a signals
Illustrated

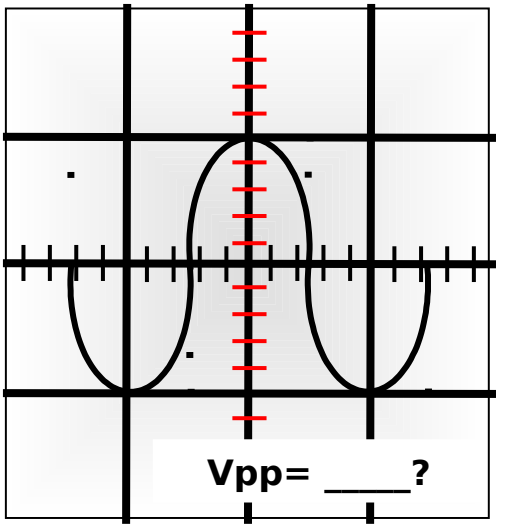


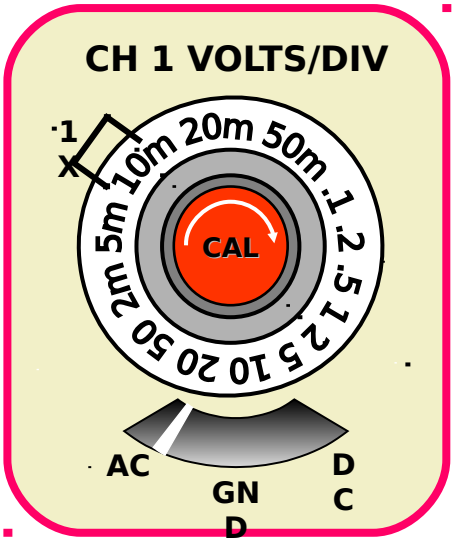


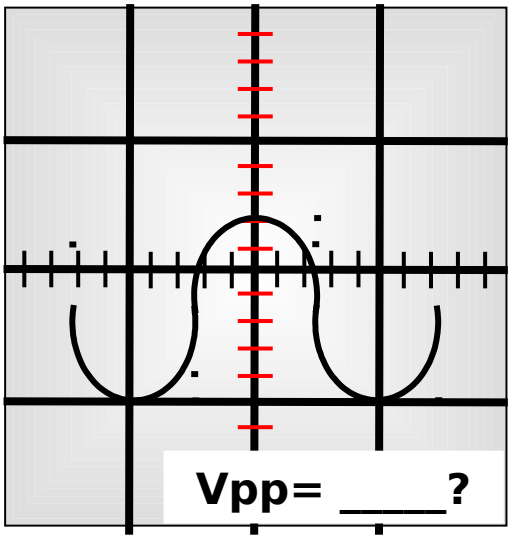






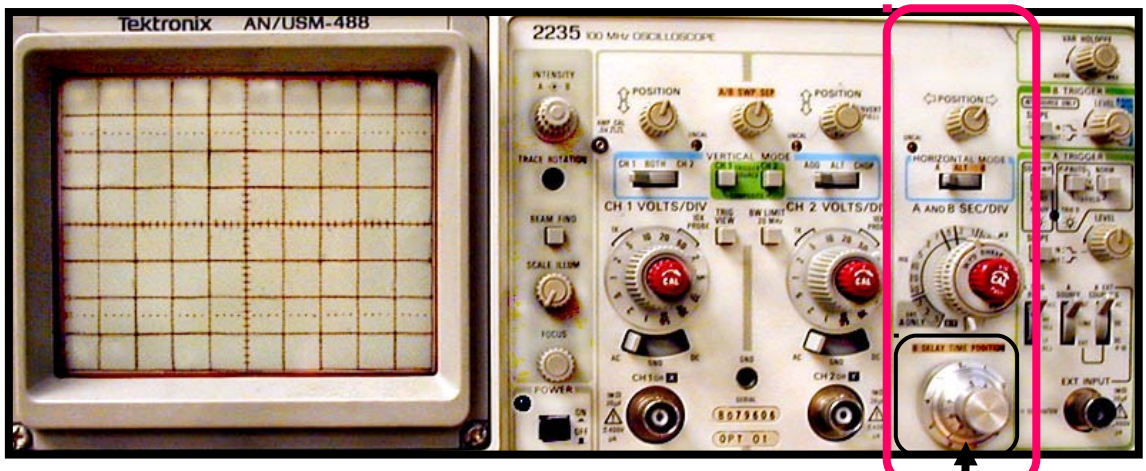


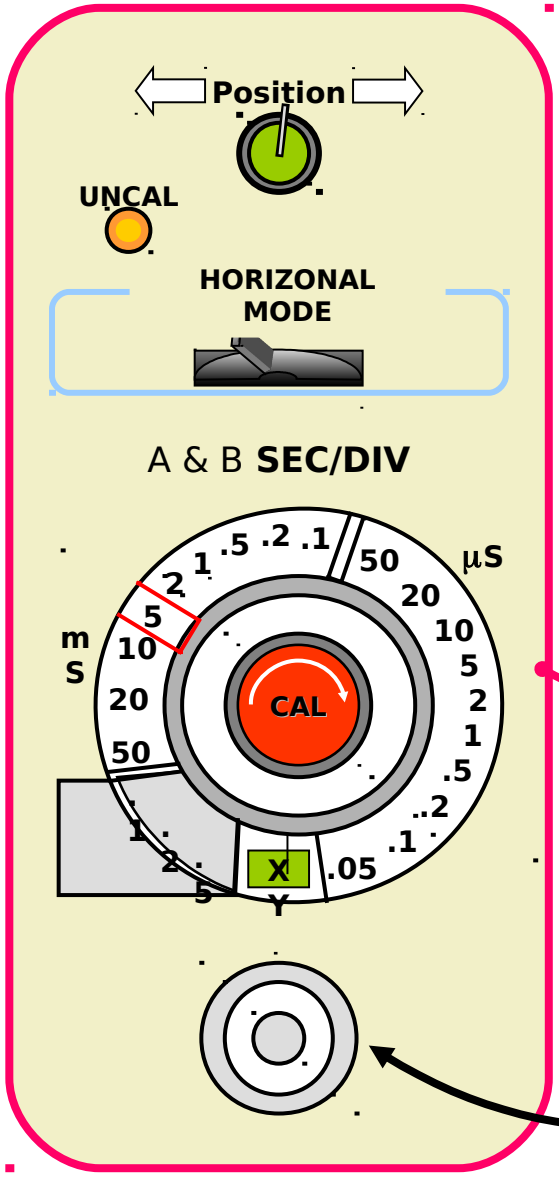




 # BLOCKs X VOLTS/Div

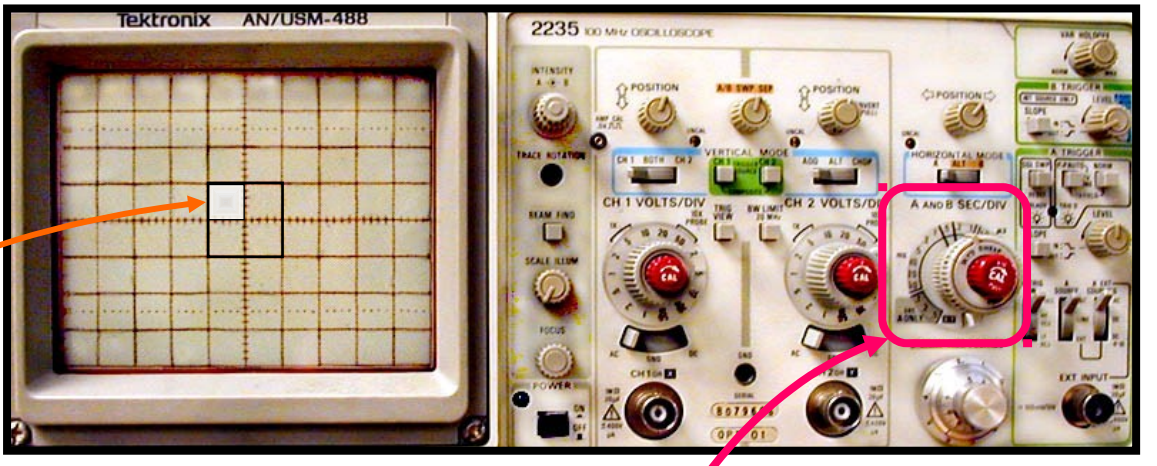
Oscilloscope; Seconds Per Division.

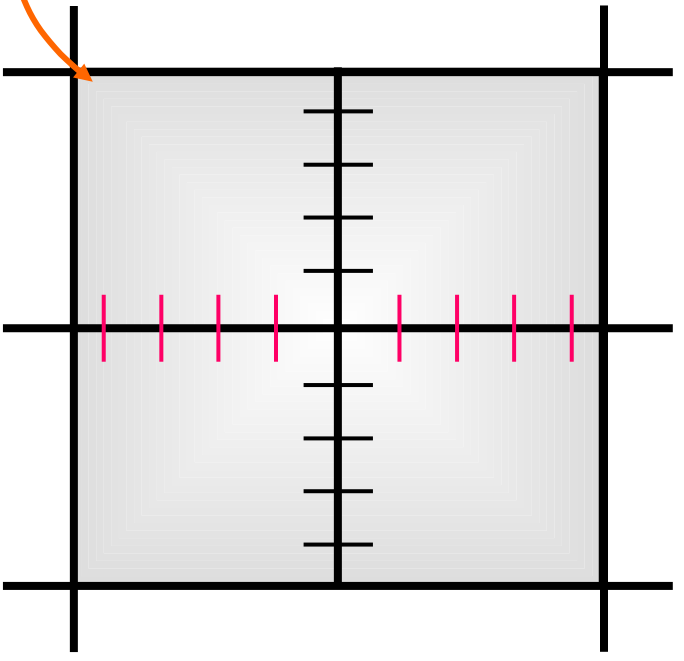


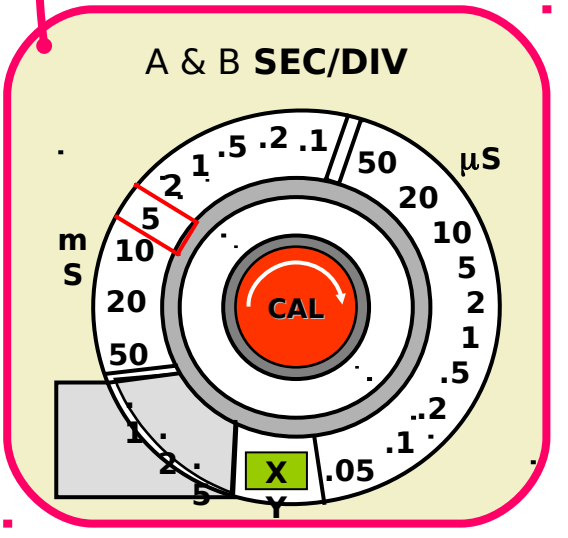


AC: Test Equipment

Oscilloscope; Determine the Value of the Seconds Per Division.



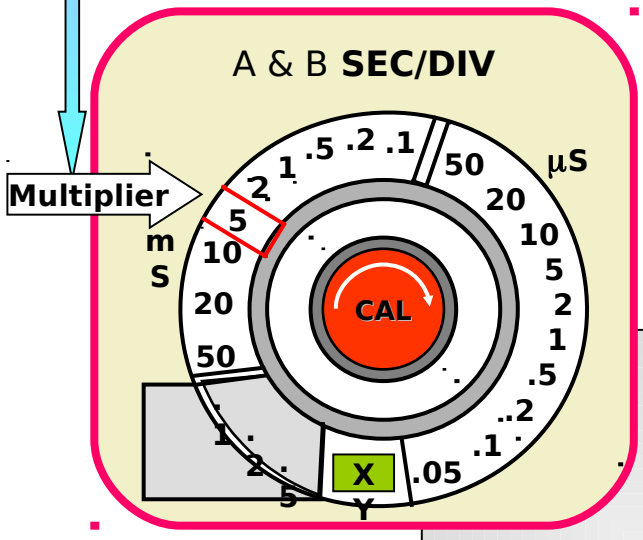


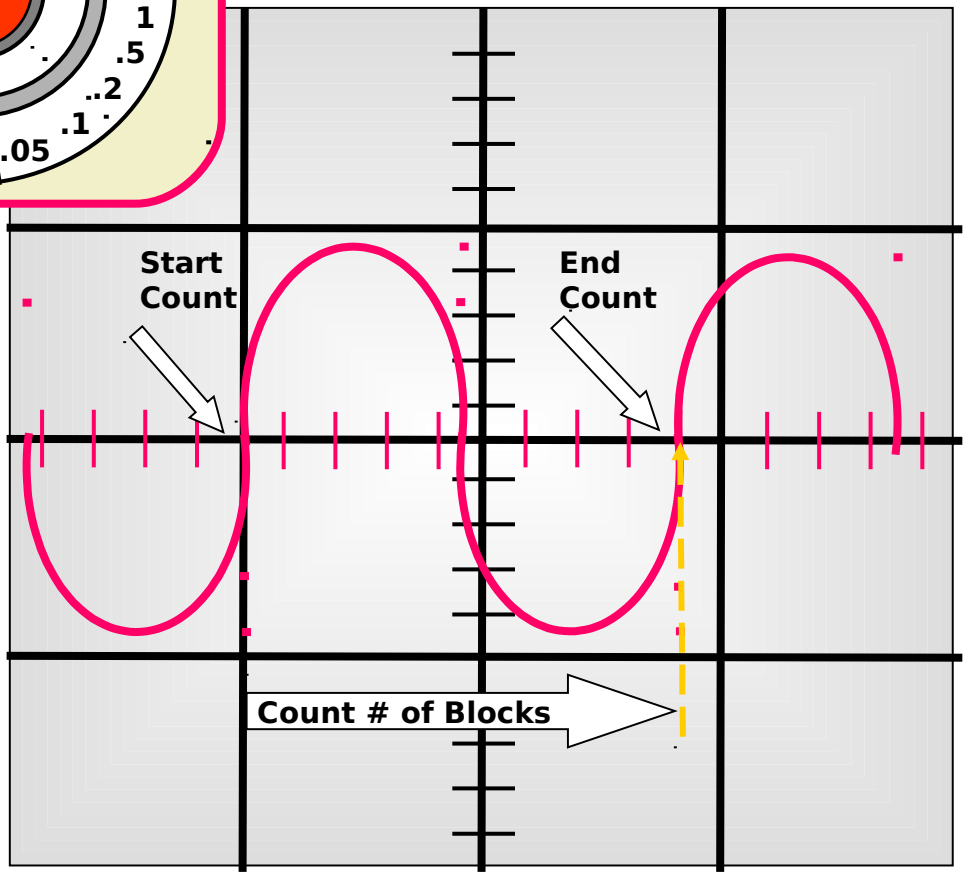


Oscilloscope; Calculating the PERIOD.

The Number of BLOCKs X Setting of SEC/Div = PERIOD

1.8 X 5 mS = 9 mS





To Determine Frequency:

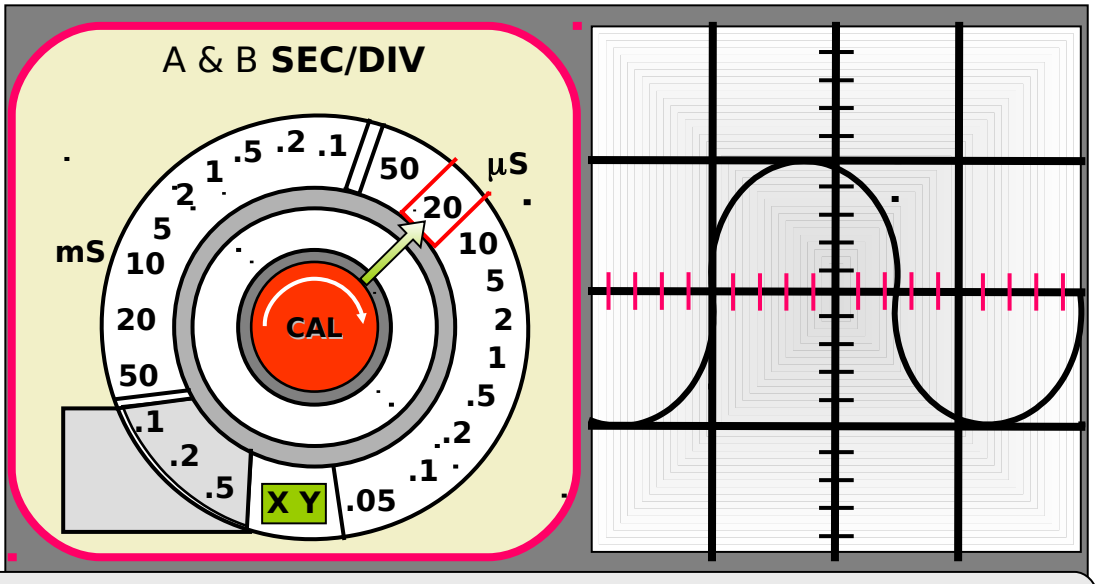
Period 1/X = Frequency

9 mS 1/X = 111.11 Hz

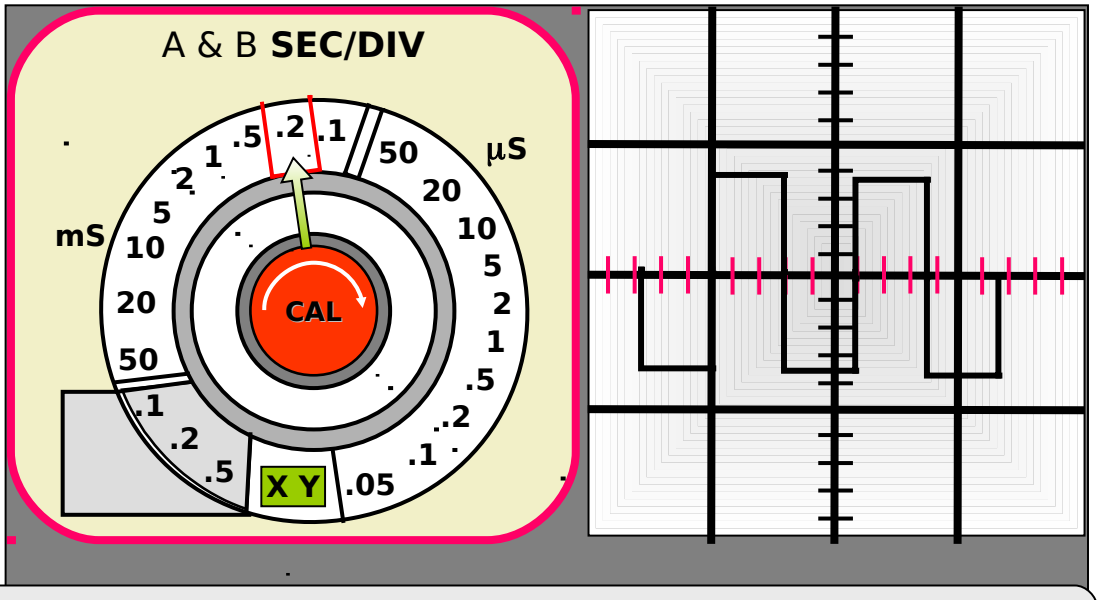
AC: Test Equipment

Oscilloscope;

Calculate the PERIOD, PW & FREQUENCY for each illustration.



P = _____? PW _____? Freq _____?

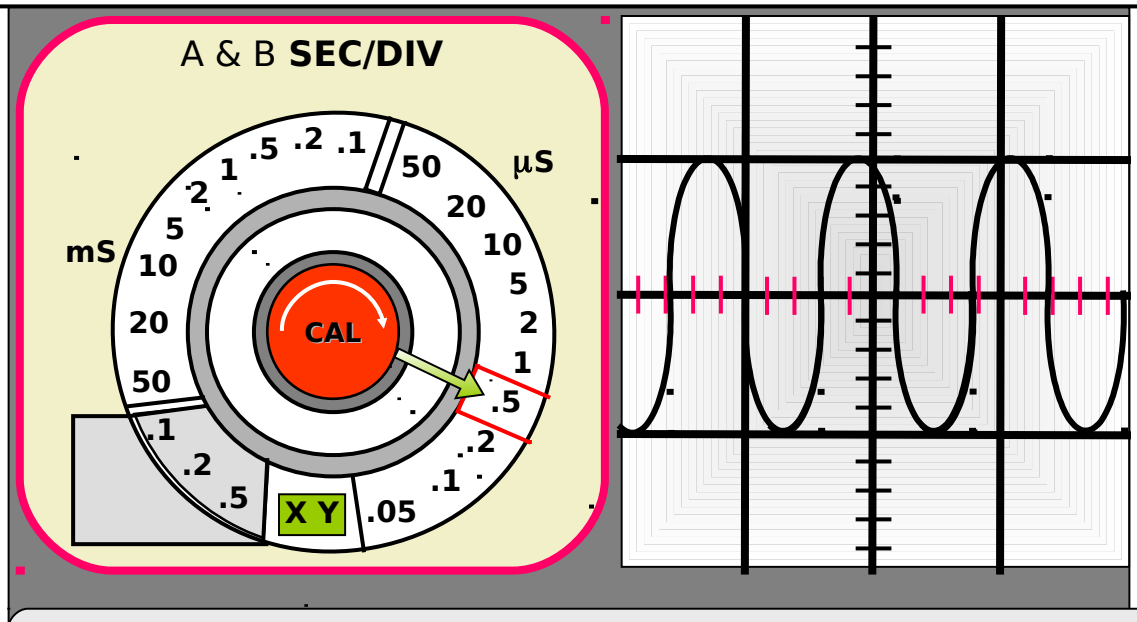


P = _____? PW _____? Freq _____?

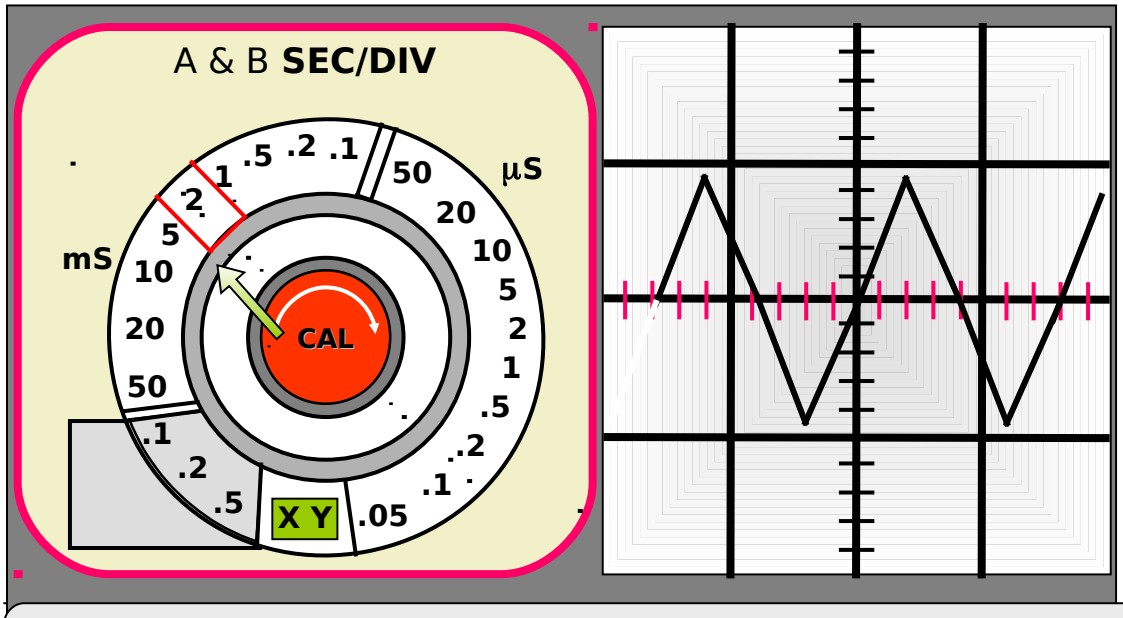
NOTE: :Slide shows 4 illustrated problems. Two on this page & two on the next.

Oscilloscope;

Calculate the PERIOD, PW & FREQUENCY for each illustration.



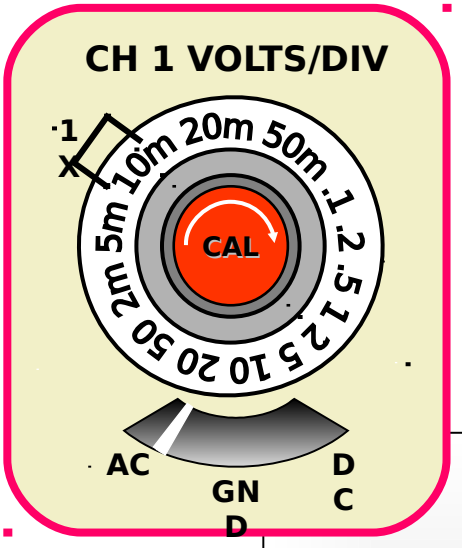
P = _____? PW _____? Freq _____?

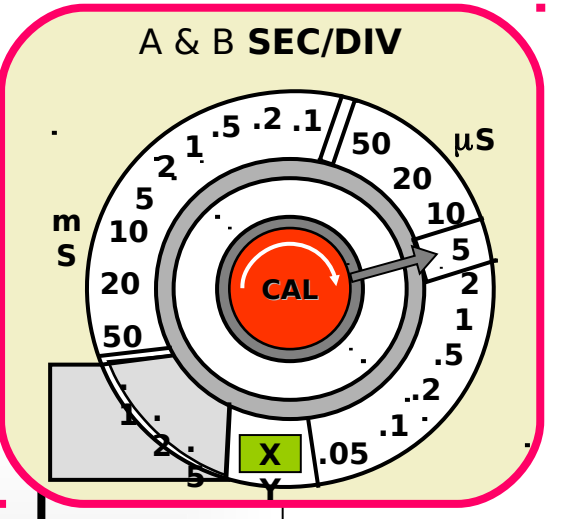


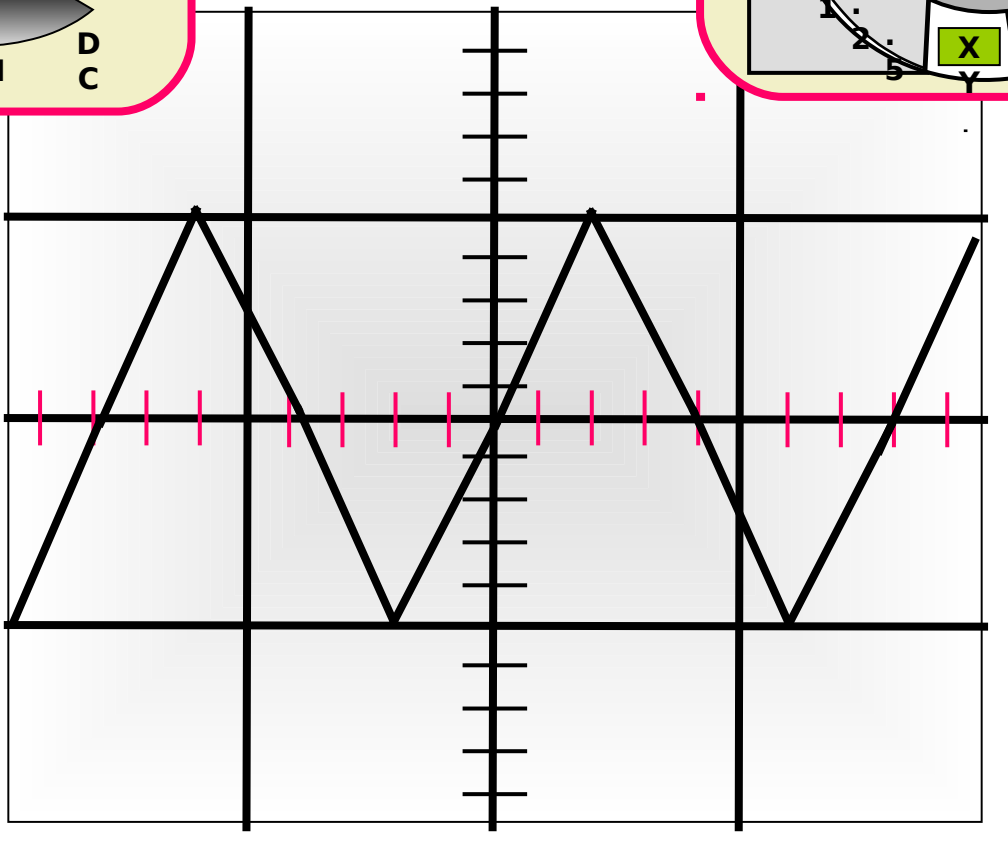
P = _____? PW _____? Freq _____?

AC: Test Equipment

Oscilloscope; Calculate the P, PW, Freq, & Voltage.



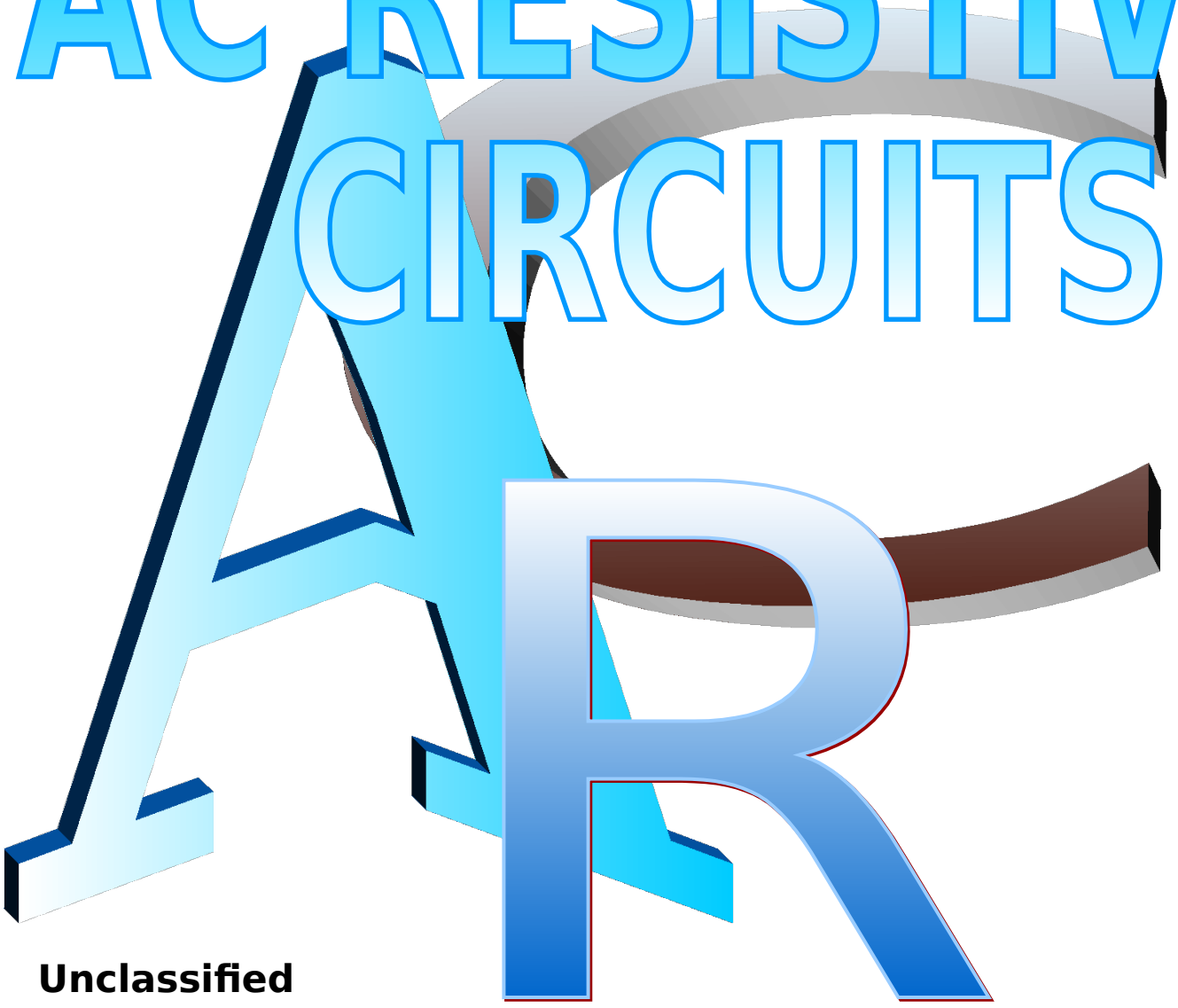




P = _____? **PW ____?** **Freq ____?**

Vpp = _____?

AC RESISTIVE CIRCUITS



Unclassified

Safety & Environmental Impact is "LOW"

In previous lessons we dealt with resistors, resistor color code, determining total resistance, and how resistors functioned in DC circuits.

Resistors operate the same in AC Circuits as they did in DC circuits. The change is the type of AC voltage used, (Eff/RMS, Peak, & Peak/Peak) will change the numeric value of the operating parameters in the Ckt.

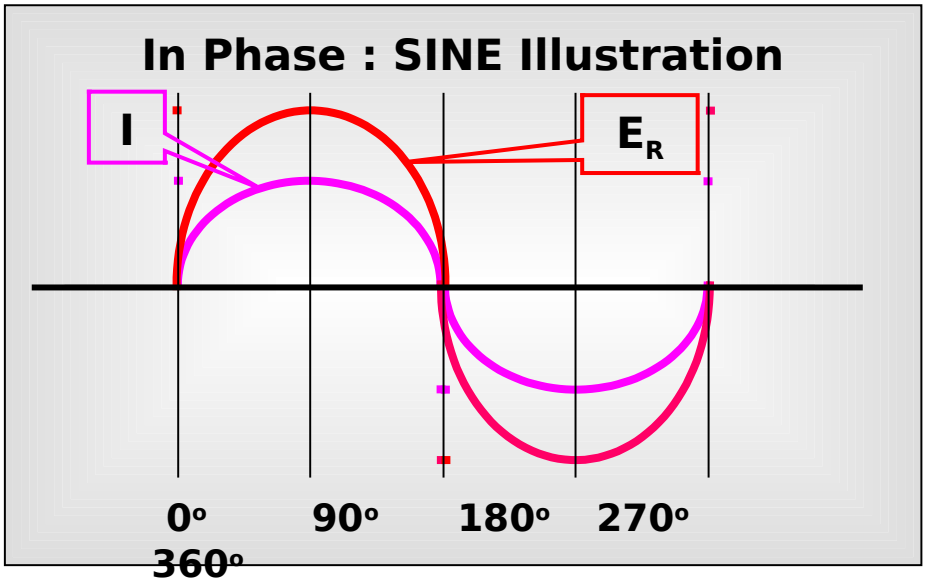
AC: Resistive Ckt; Phase Relationships

Phase Relationship; The Sine & Vector illustrate the same Concept.

Sine; O-scope Display, Voltage and Current are in phase.

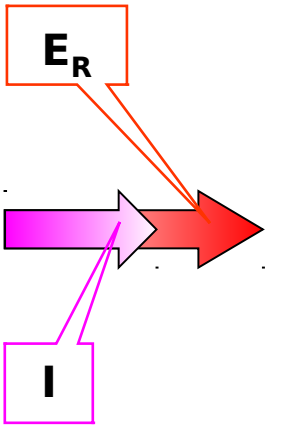
Vector; Mathematical expression

Changes in frequency does not change resistance or voltage drops on the resistor.

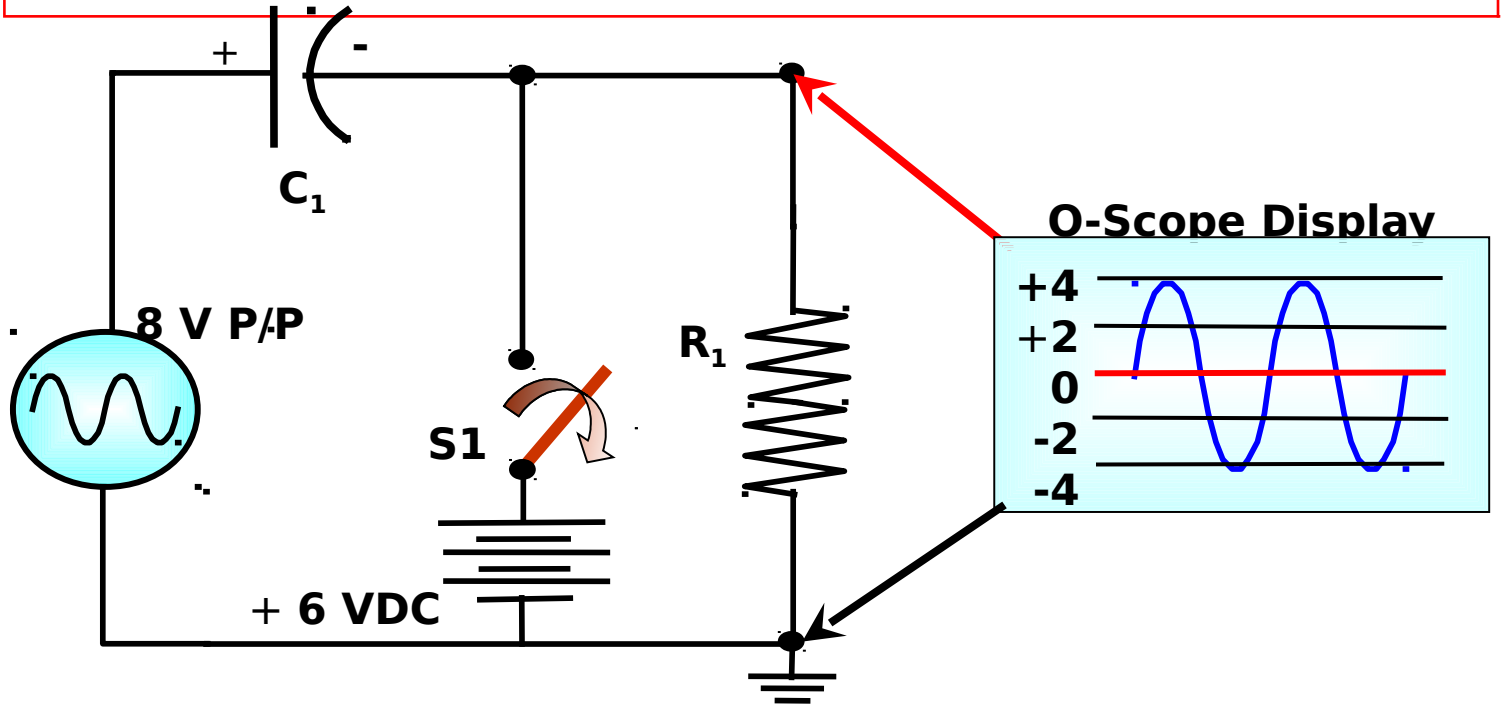


In Phase:

VECTOR Illustration



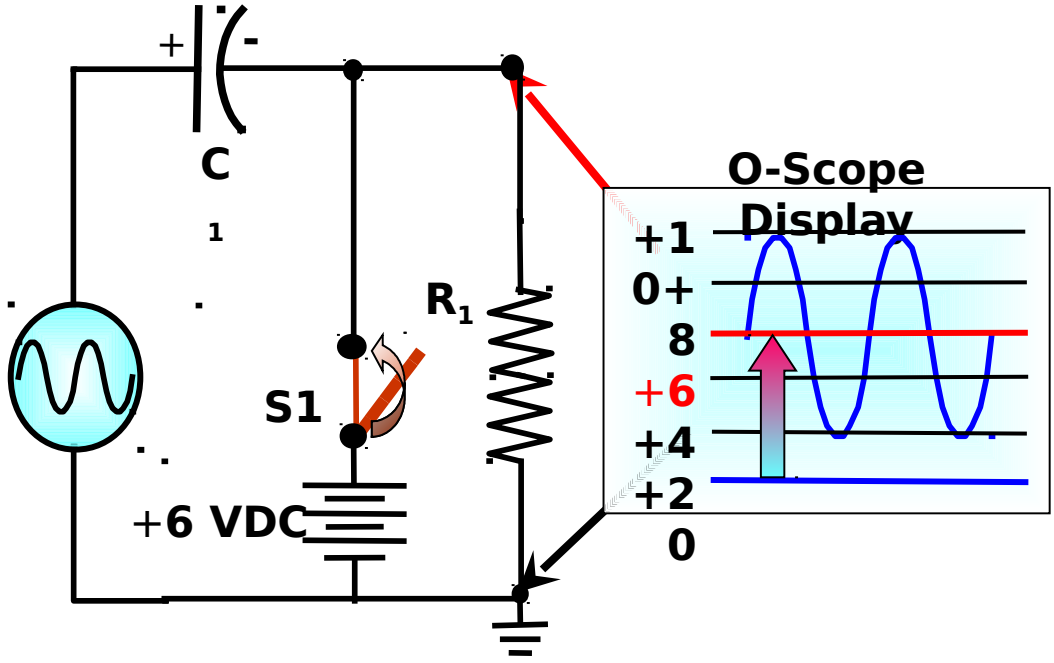
Electronic circuits will have both AC and DC operating in them.
W/S1 OPEN the AC rides on the 0 Volts reference line.



AC: Resistive Ckt; Concept

With S1 Closed the AC will have a new reference.

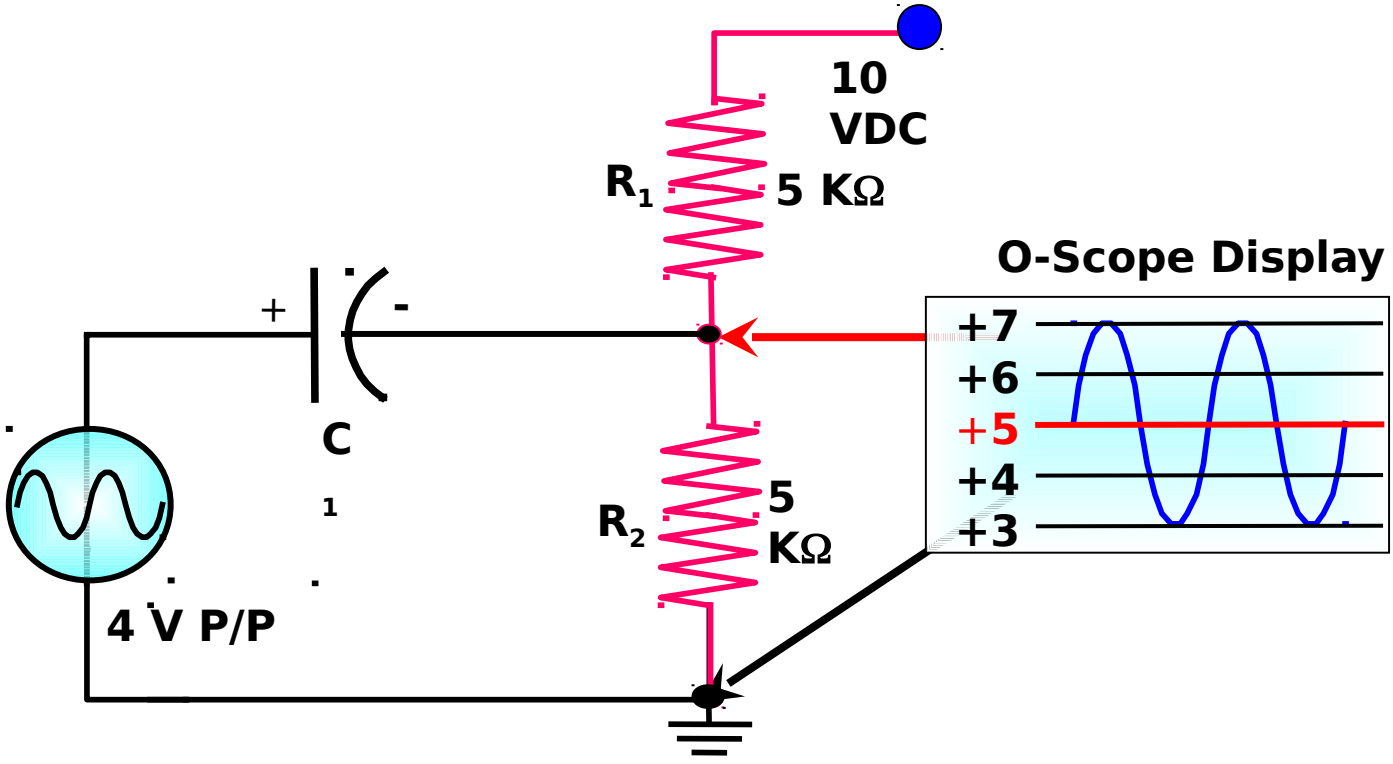
Note: The Reference has moved from, 0 Volts to 6 Volts DC.



What is the Value of the AC Displayed on the Scope?

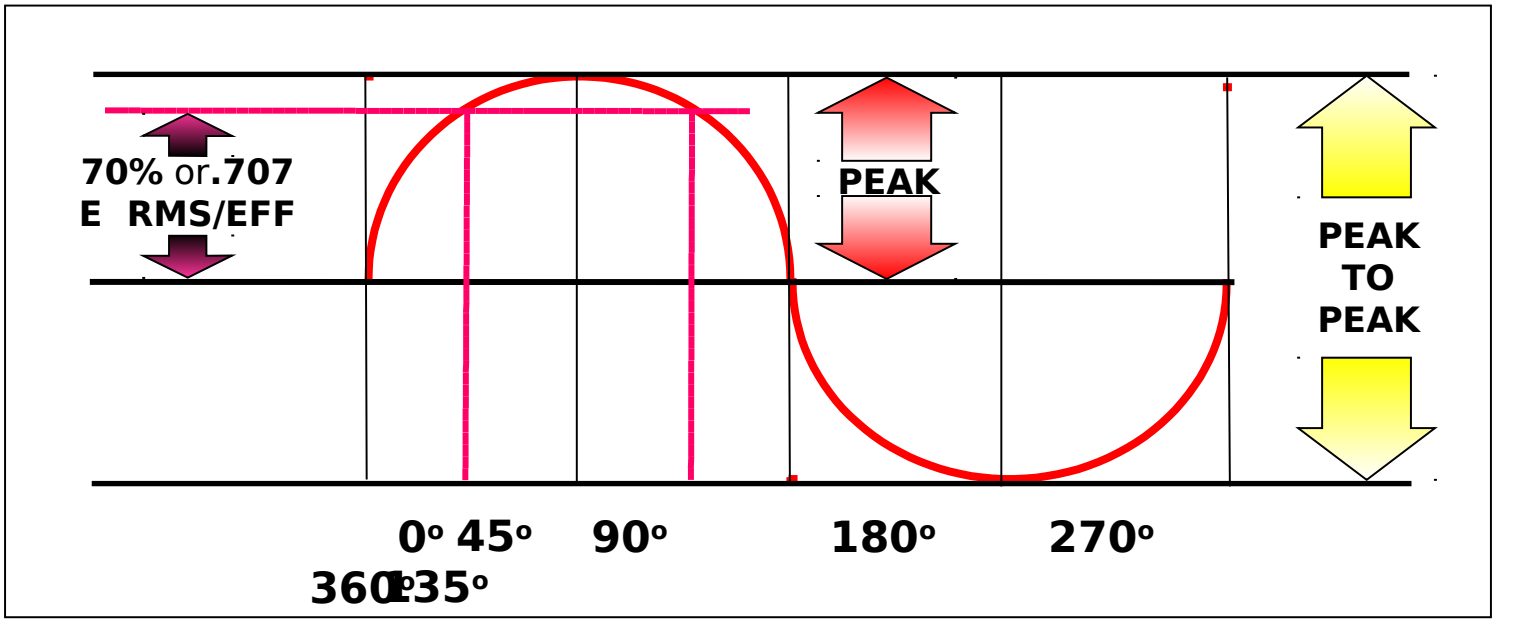
10 - 2 = ___V_{PP} ?

R1 & 2 is a DC Voltage Divider. The O-Scope is displaying the Voltage Drop of R_2, [E_{R2}] The AC Signal is riding the DC.

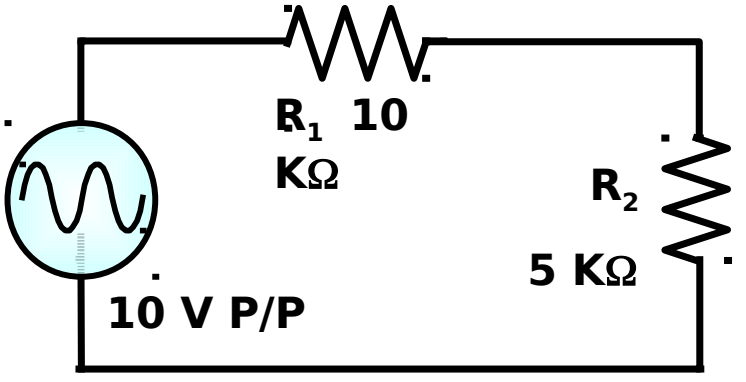


AC: Resistive Circuits

AC Voltages;



Calculate, the operating parameters of the Ckt below.



Kirchhoff's Law

Expressed Mathematically as:

$E_A = E_{R1} + E_{R2}$

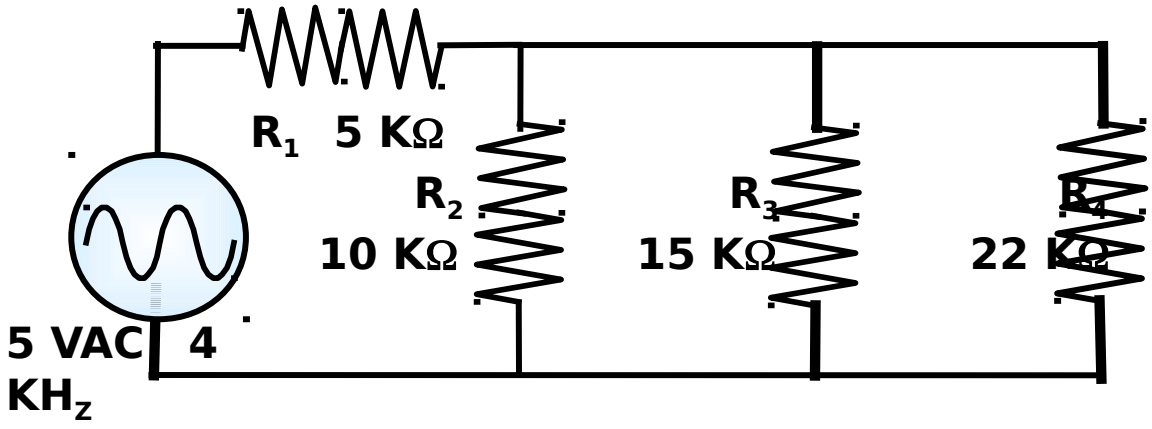
and Ohm's Laws still apply in AC resistive circuits

E_A	_____	$E_{R1} + E_{R2}$
R_T	_____	$R_1 + R_2$
I_T	_____	$E_A \div R_T$
E_{R1}	_____	$I_T \times R_1$
E_{R2}	_____	$I_T \times R_2$

E_A	_____	RMS
R_T	_____	
I_T	_____	
E_{R1}	_____	
E_{R2}	_____	

AC: Resistive Circuits

Calculate; Operating parameters in VAC P/P & VAC P.



E_A = 5 VAC	E_A = _____P/P	E_A =_____ PK
R_{EQ} = 4.71 KΩ	R_{EQ} = _____	R_{EQ} = _____
R_T = 9.71 KΩ	R_T = _____	R_T = _____
I_T = .515 mA	I_T = _____	I_T = _____
E_{R1} = 2.575 VAC	E_{R1} = _____	E_{R1} = _____
REQ	REQ _____	REQ _____
VAC		

Summary

AC Resistive Circuits is a review of Series, Parallel, and <u>Series/Parallel</u> Circuits.

Ohm's and Kirchhoff's Laws are still valid in the calculations for AC Resistive Circuits.

Voltage and Current are <u>in phase</u> in AC Resistive Circuits.

Changes in frequency <u>DOES NOT</u> affect resistance values its voltage drops.

AC:

056 SLIDE;

AC INDUCTIVE CIRCUITS

Unclassified

Safety & Environmental Impact is "LOW"

In previous lessons we dealt with the resistor as the opposition to the flow of current. In this lesson we will look at our 1st frequency sensitive component. Its value of opposition will change with the change in frequency.

The Inductor is a reactive component & since its opposition cannot be measured it must be calculated.

AC: Inductive Ckt, Concepts

INDUCTOR;

Opposes any <u>change</u> in Current, & stores energy in an Electromagnetic Field.

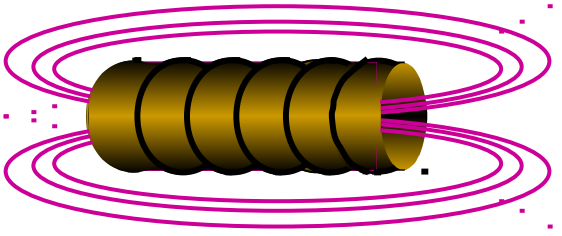
It may be called a, Choke or a Coil.

Inductor Symbol; L

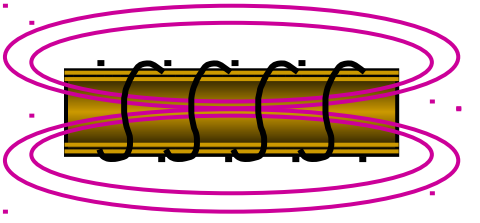
Unit of Measure; henrys, h *lower case* **, mh** milli henrys**;**

Iron core versus Air core;

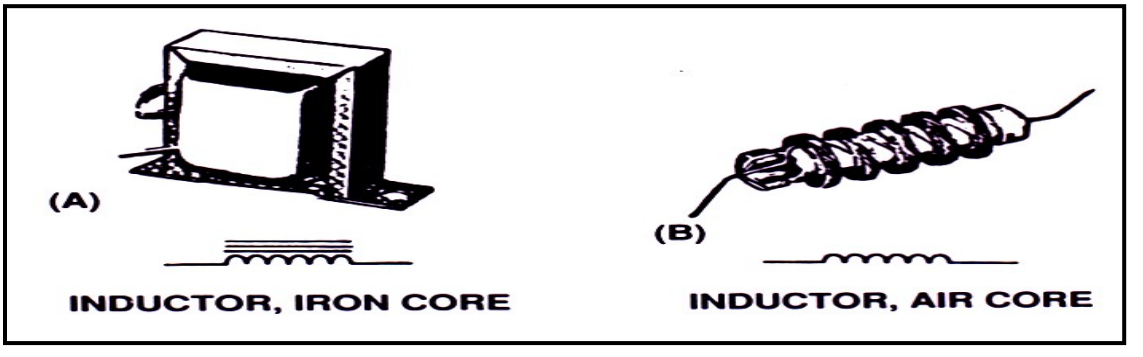
Iron is used in low frequency & power applications. Iron increases the permeability or strength of the magnetic fields. Air core is used in high frequency applications, where signal information has priority.



Iron Core



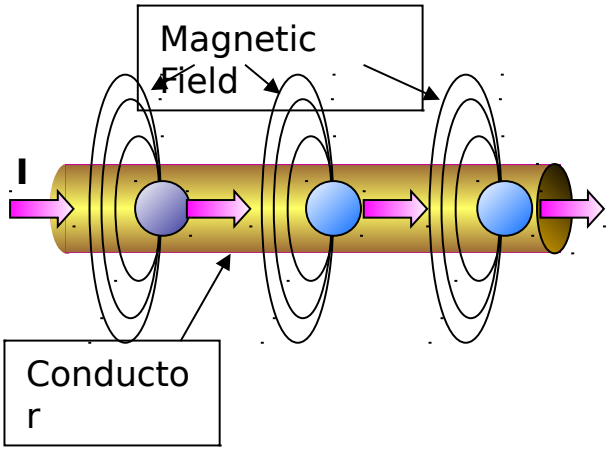
Air Core



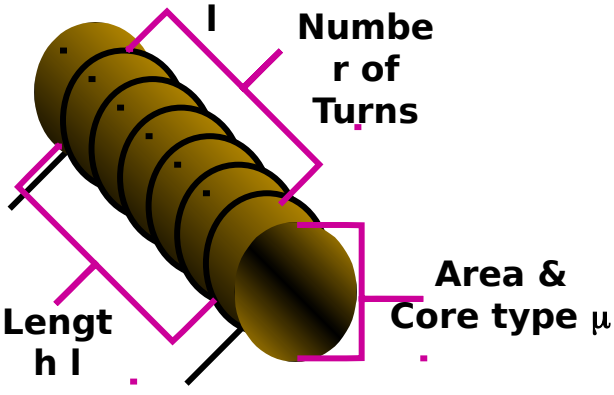
AC: Inductive Ckt, Concepts

As Current flows through a conductor a magnetic field is produced. By winding a conductor w/in a small area and concentrating the magnetic Field, an Inductor is produced.

The factors that determine the value of an Inductor, are assembled & calculated mathematically to determine the value of the Inductor.



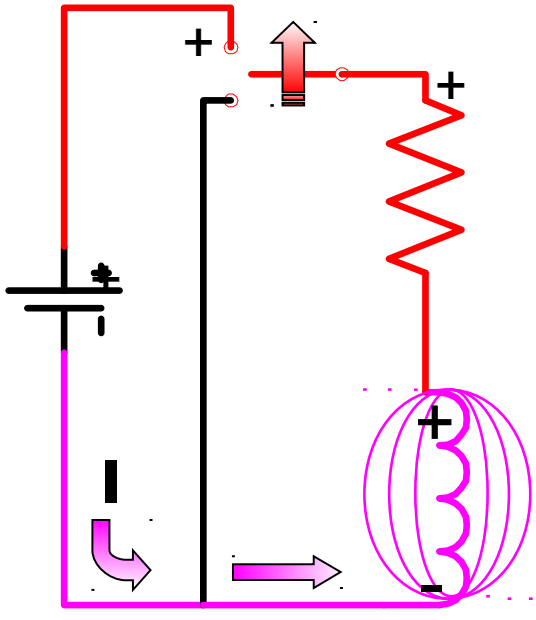
L = μ X Area X Num ²

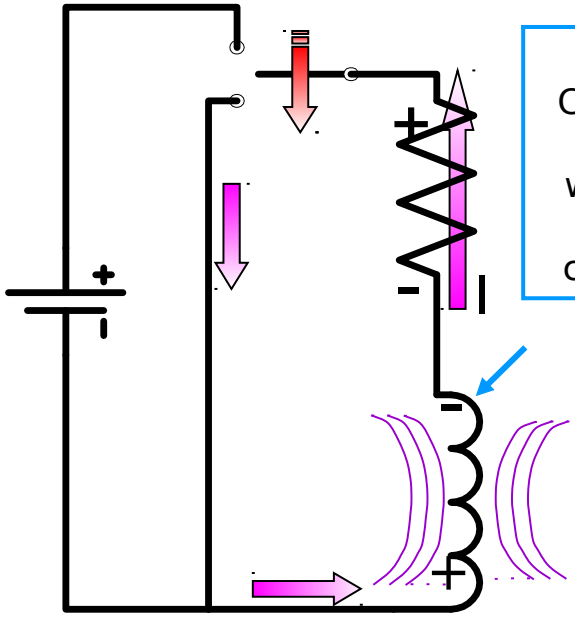


Induce or Induct;

The ability of an inductor to store energy in an electromagnetic field and return that energy to the Ckt, in the form of Current.

This ability is dependent upon change, AC offers that change.



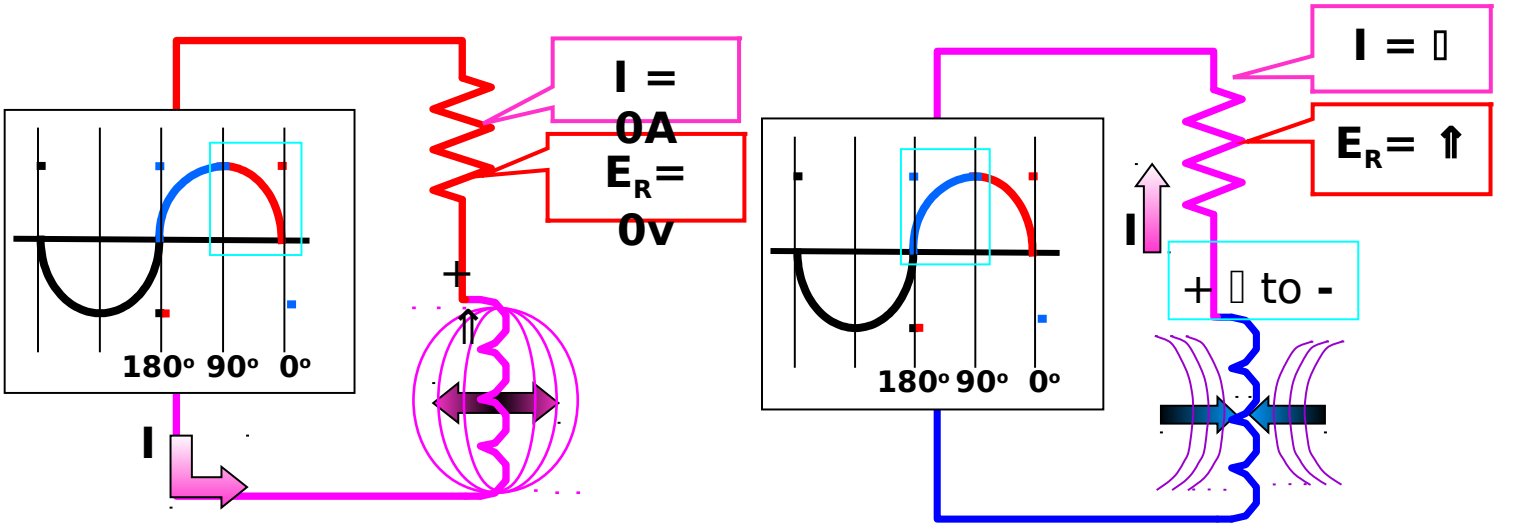


Note: Change in polarity when the field collapsed

AC: Inductive Ckt, Concepts

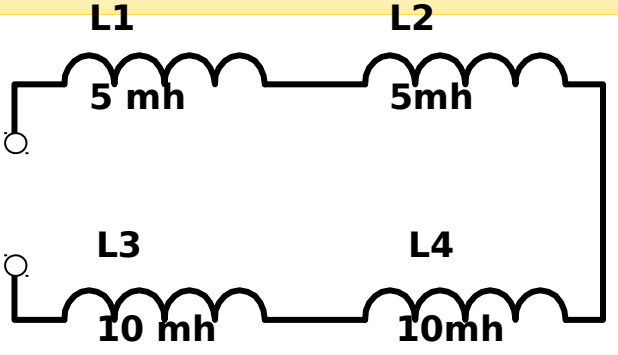
Induce or Induct;

The Inductor is dependent upon change. The ability to convert Current Energy to Electromagnetic energy, then back to Current. This occurs with the change of polarity of the AC waveform.



Starting @ 0 V reference the AC signal becomes progressively more positive and Current flow ↑, as this flows hits the Inductor a change in energy takes place, current energy is changed to Electromagnetic energy & stored, this continues until the AC signal reaches 90° & polarity is @ its maximum, the voltage drop across the resistor is 0V, this because there is no current flow thru the Inductor & resistor, it is being stored in the inductor. The Ckt is acting Like an open. Only when the Ac signal exceeds 90° & the polarity starts to decrease & the magnetic fields collapse then inducing current back into the Ckt, {magnetic energy is changed back into current} , current will leave the Inductor & flow thru the resistor & develop a voltage drop. Hence a Phase shift of voltage & current will be observed, More on the phase shift latter in this lesson.

LT: Inductors in Series; are Additive like resistors in Series.



$L_1 + L_2 + L_3 + L_4 = L_T$

5 mh + 5mh + 10 mh + 10 mh = 30 mh

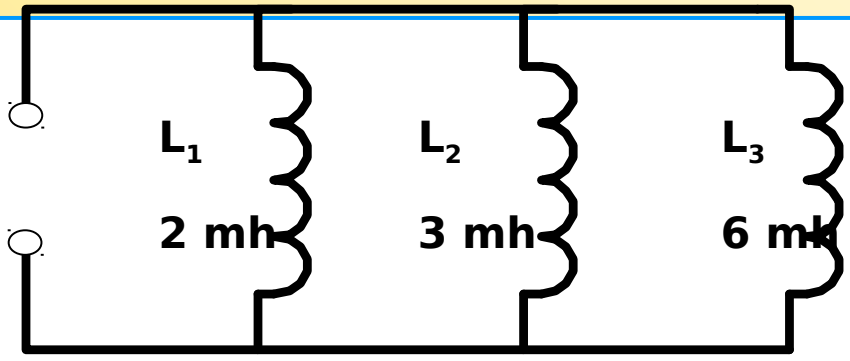
LEQ & LT Inductors in Parallel;

Are calculated like resistors in Parallel.

Like Value, Product over the Sum & Reciprocal methods

The LEQ will be smaller than the smallest value Inductor in the Parallel Ckt. [L_{EQ} < 2 mh]

L_1 1/X + L_2 1/X + L_3 1/X … = 1/X ⇒ L_{EQ}



NOTE:

The LEQ & LT will be the same, in a Pure Parallel Ckt.

2 mh 1/X + 3 mh 1/X + 6 mh 1/X = 1/X ⇒ 1 mh

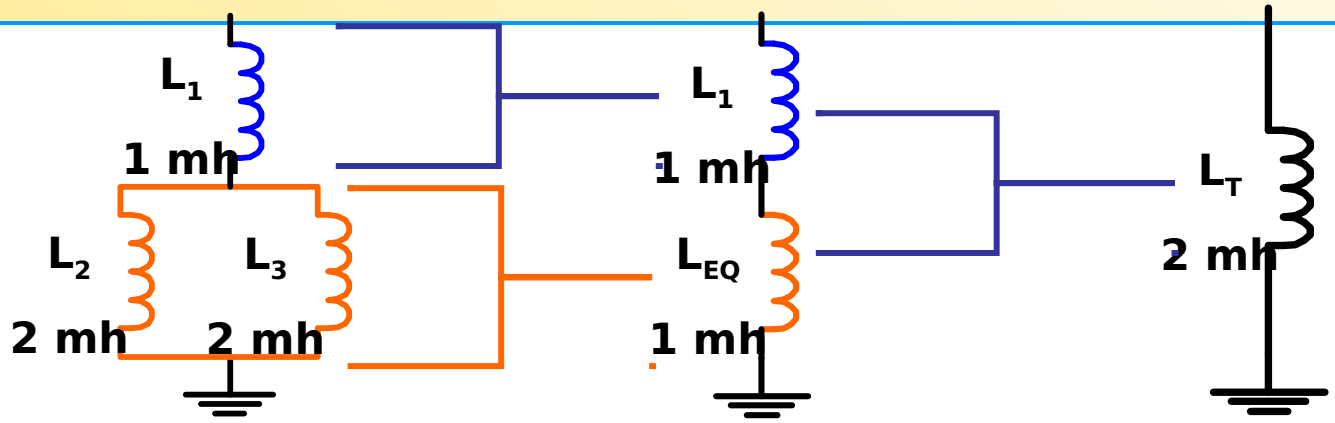
Inductors in Series Parallel;

Are calculated like resistors in a Series Parallel Ckt.

Just like Resistors, this will reduce the Ckt values down to a single value of Inductance Total, LT.

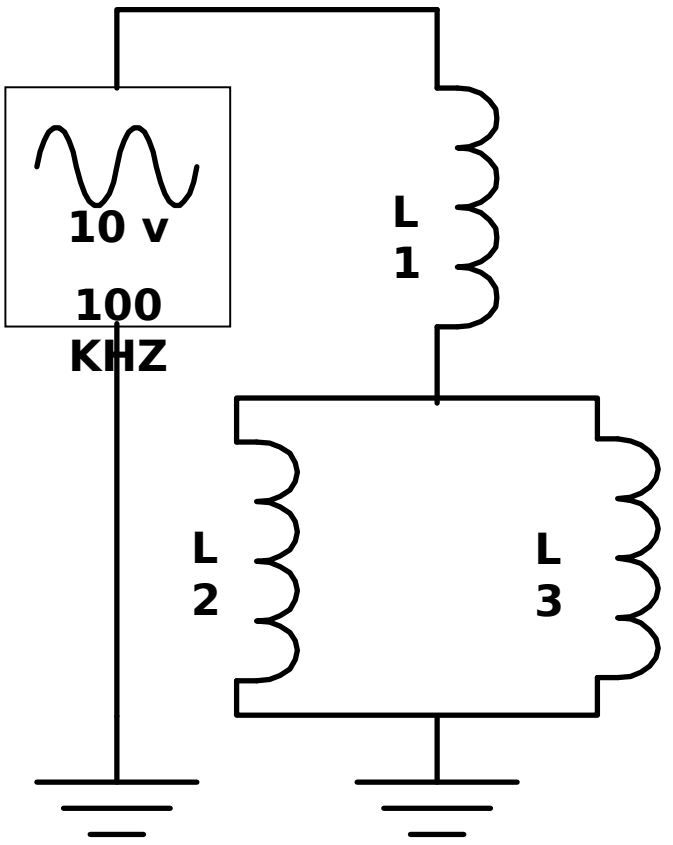
Calculate for the LEQ and Add the Inductors in series.

L_{EQ} + L_1 = L_T



AC: Inductive Ckt, LEQ, LT & XL.

Calculate; the values LEQ, LT, Period & Pulse Width.



A.

L1 = 10 mh
L2 = 30 mh
L3 = 30 mh

EA = _____
LEQ = _____
LT = _____
P = _____
PW = _____

B.

L1 = 3 mh
L2 = 4 mh
L3 = 5 mh

EA = _____
LEQ = _____
LT = _____
P = _____
PW = _____

Reactance;

Because The inductor is a Frequency sensitive device, it will change in value of opposition as the Frequency changes. Since its value cannot be measured it has to be calculated, with frequency as part of the equation.

Reactance, Symbol; X Unit of Measure; Ω Ohms

Inductive Reactance; X_L Unit of Measure; Ω Ohms

$X_L =$

"2 Pies For Lunch"

2 π F L

2 π X Frequency X Inductor

Ω

AC: Inductive Ckt, XL.

X_L =

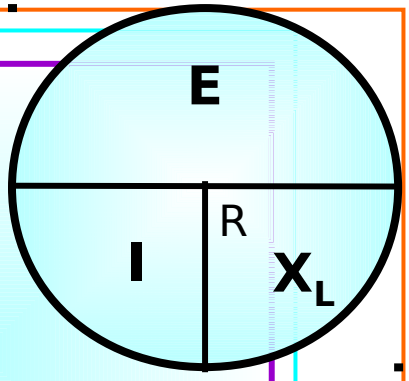
"2 Pies For Lunch"

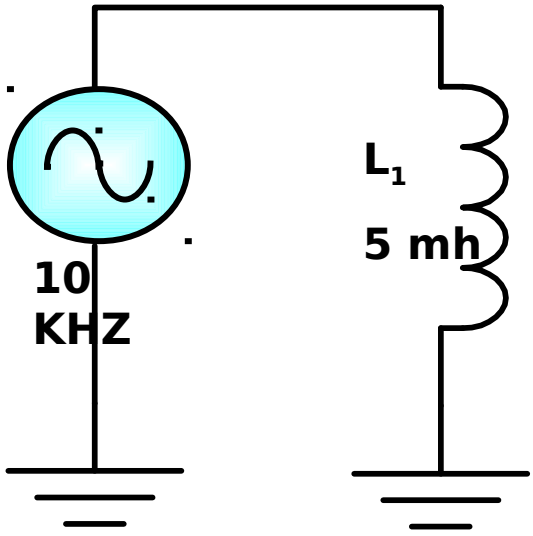
2 π F L

2 π X Frequency X Inductor

6 .28 X Freq X Ind. = XL in Ω

Ω





2 π F L

6 .28 X Freq X Ind. = X_L in Ω

6.28 X 10 KHZ X 5 mh = X_L

XL = 314 Ω

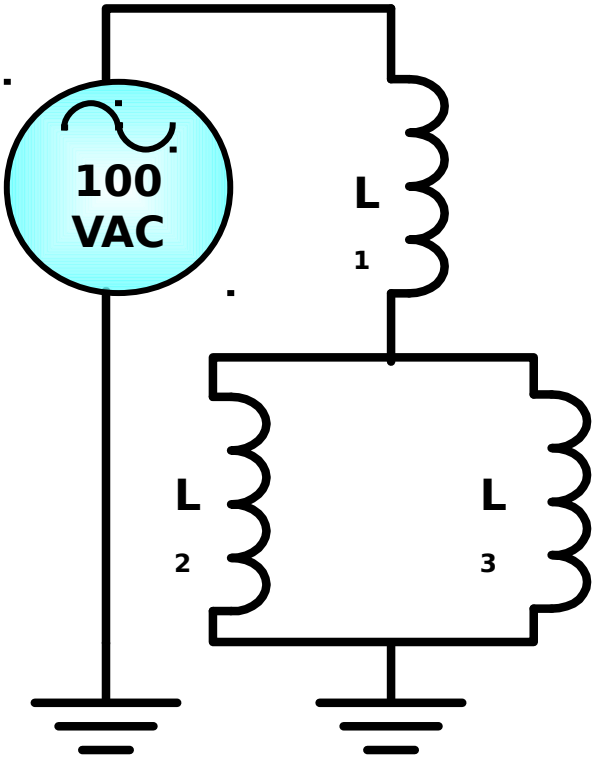
On the Calculator:

6.28 X ~~10 EE^3~~ X ~~5 EE^{-3}~~ =314 Ω

AC: Inductive Ckt, XL.

Calculate for the values LEQ, LT, XLT.

[No Rounding & carry Decimal 2 places].



A.

L1 = 3 mh EA = _____

L2 = 4 mh LEQ = _____

L3 = 5 mh LT = _____

Freq = 8 KHZ XLT = _____

B.

L1 = 3 mh EA = _____

L2 = 5 mh LEQ = _____

L3 = 6 mh LT = _____

Freq = 10 KHZ XLT = _____

Calculate the value of X_L . [No Rounding].

F = 6 KHZ L_1 = 3mh X_{L1} = _____

F = 8 KHZ L_1 = 3mh X_{L1} = _____

F = 10 KHZ L_1 = 3mh X_{L1} = _____

F = 10 KHZ L_1 = 5mh X_{L1} = _____

F = 10 KHZ L_1 = 8mh X_{L1} =

AC: Inductive Ckt.

XL & Freq Relationship:

A <u>DIRECT RELATIONSHIP</u> exists between the **XL and <u>Frequency</u> and** the size or **<u>Value of the Inductor</u>.**

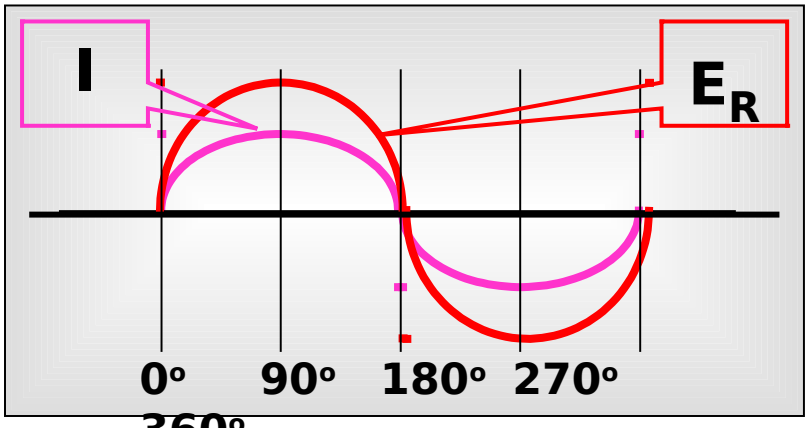
$2 \pi F L = X_{LT}$ in Ω

X_L in Ω Then E_L

<u>Phase Relationship</u>;

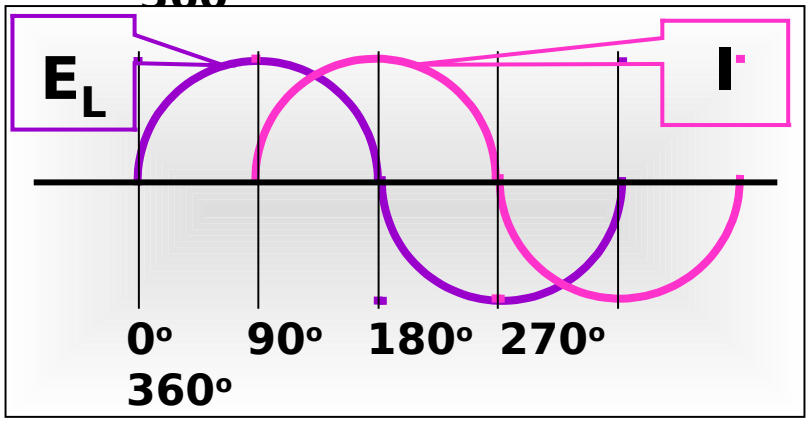
Describes the relation between Voltage across a inductor an Current through an inductor.

"Voltage Leads Current By 90°"



In Phase; SINE Illustration.

Voltage across a Resistor, ER & Current, I.



90° out of Phase; SINE Illustration.

Voltage across an Inductor, EL leads Current, I by 90°.

AC: Inductive Ckt.

Phase Relationship;

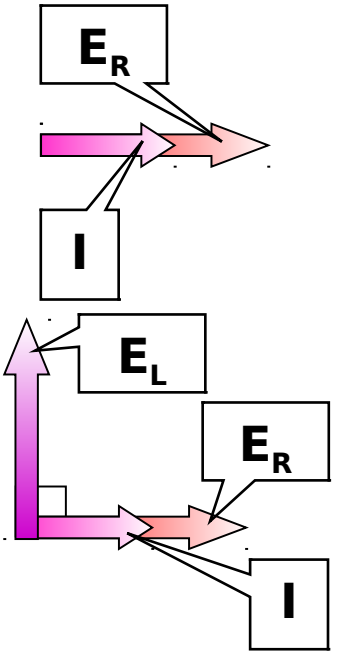
Voltage Leads Current By 90°

E L I the ice man is 90° years old

In Phase;

VECTOR Illustration

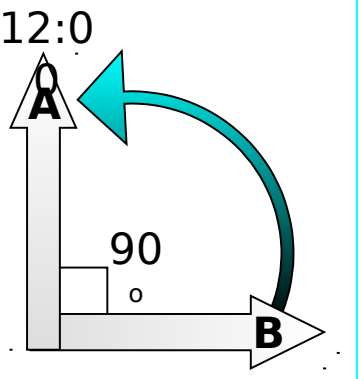
Voltage across a Resistor, ER & Current, I.



90° Out of Phase;

VECTOR Illustration

Voltage across an Inductor, EL leads Current [I] by 90°. Or I Lags the EL by 90°.



Reading the Vector:

Rotating in a counter clockwise direction, entity A is leading B by 90°.

The length of the RAY expresses the Amplitude of the entity.

Phase Relationship;

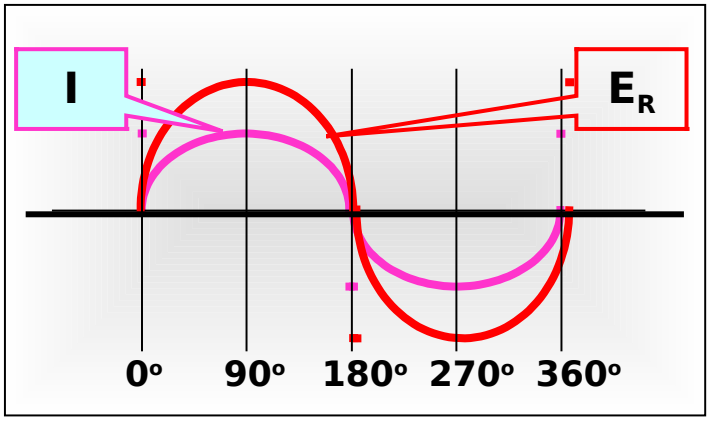
The Sine & Vector illustrate the same Concept.

Sine; O-scope Display,

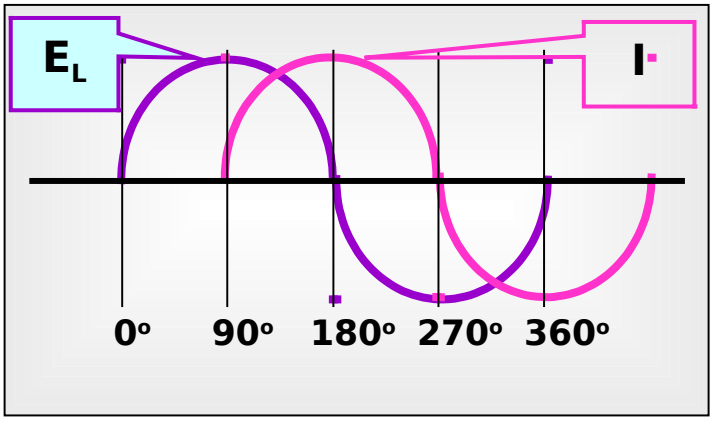
Vector; Mathematical expression

The Lag time of current is due to the expansion of the field

SINE Illustration;
In Phase



SINE Illustration;
90° out of Phase



AC: Inductive Ckt.

Current & Voltage Drops;

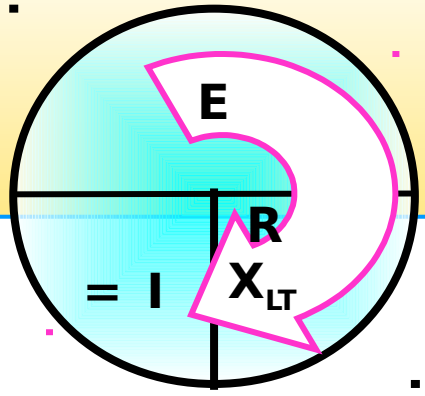
In a Purely Inductive Ckt [a Ckt w/just Inductors].

Current can be calculated using Ohms Law by using the applied voltage over the opposition of the Inductor.

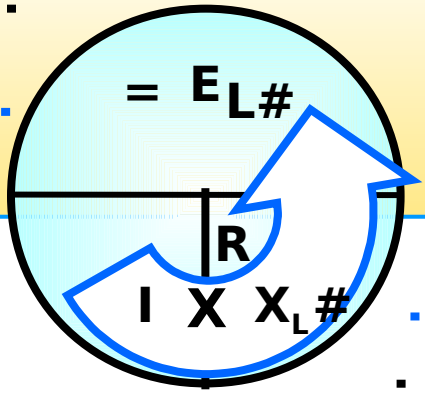
$$EA \div X_{LT} = I_T$$

Voltage drops can be calculated using Ohms Law under the same conditions.

$$I_T \times X_{L\#} = E_{L\#}$$



It is very unlikely to have a purely Inductive Ckt.



IMPEDANCE;

In a Ckt containing more than one type of Opposition; A Resistor, a non-reactive component, [does not change value w/ the change in frequency].

An Inductor, a reactive component, [changes value { XL } w/ the change of frequency].

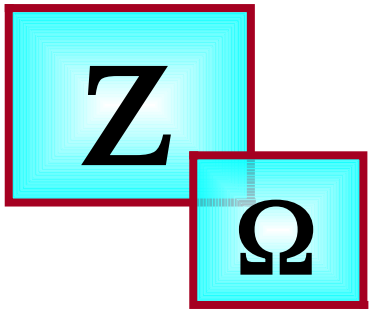
Total Opposition Will Have To Be Calculated for.

IMPEDANCE;

Is the TOTAL OPPOSITION to the flow of AC Current.

Symbol; **Z**

Unit of Measure; Ω

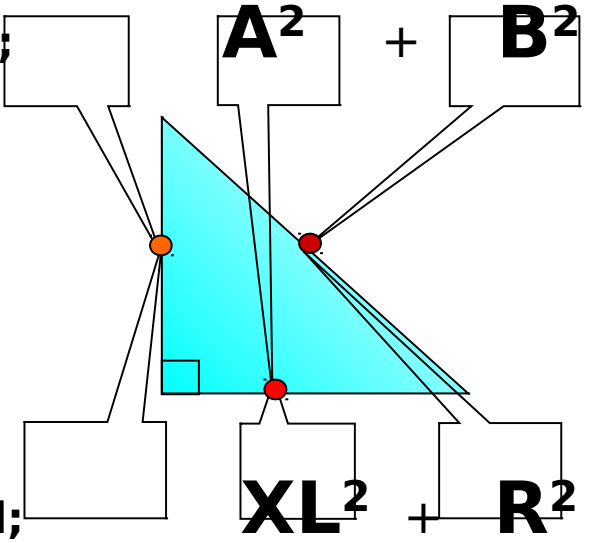


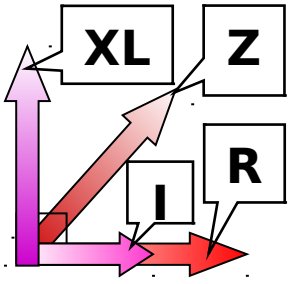
AC: Inductive Ckt .

IMPEDANCE;

Pythagoreans **Total Opposition will have to be calculated using the Theorem, often referred to as Vectored Addition.**

It States; $A^2 + B^2 = C^2$ C^2 is the Hypotenuse of a Triangle.



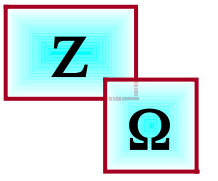


Restated; $XL^2 + R^2 = Z^2$ Z^2 is the Hypotenuse of a Triangle.

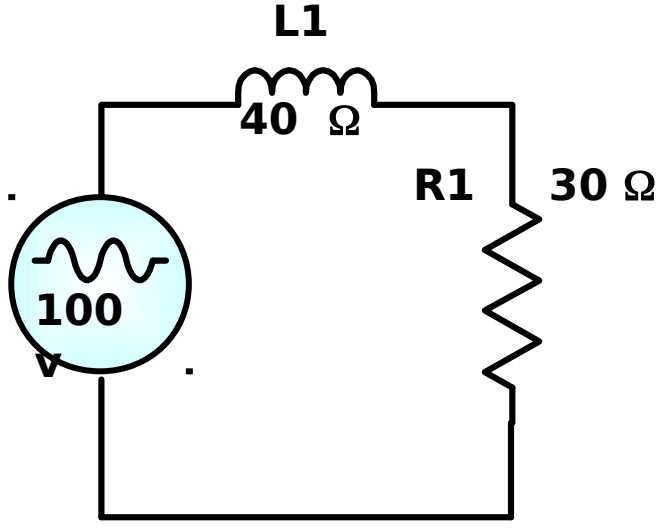
$$Z = \sqrt{R^2 + X_L^2} \quad \text{or} \quad Z = \sqrt{R_T^2 + X_{LT}^2}$$

On the Calculator:

R X^2 + XL X^2 = $\sqrt{X}$ ⇒ Z in Ω



IMPEDANCE; Calculate Impedance.

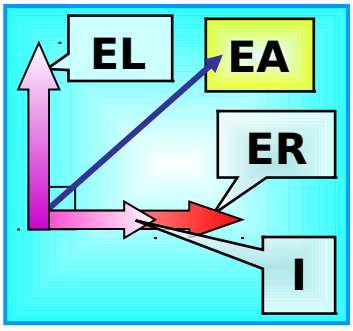


E_A =	____	
Z_T =	____	$\sqrt{30^2 + 40^2}$
I_T =	____	$E_A \div Z_T$
E_{R1} =	____	$I_T \times R_1$
E_{L1} =	____	$I_T \times X_{L1}$

AC: Inductive Ckt .

EA:

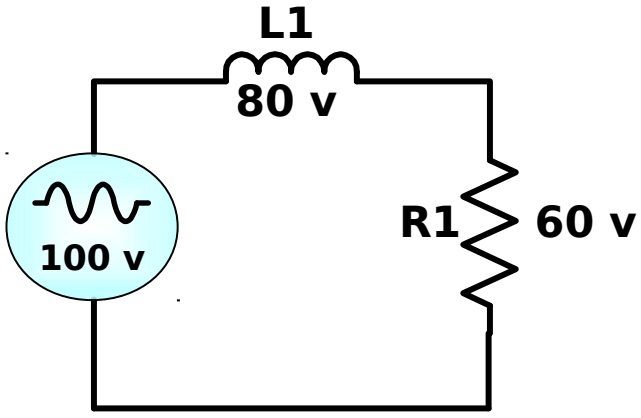
ER1 + EL1 does not = EA, The opposition was Added Vectorally. Therefore the Voltage drops must be Added Vectorally. Pythagorean's Theorem must be used as it was in solving for the total opposition.



$$EA = \sqrt{E_{RT}^2 + E_{LT}^2}$$

Calculator:

E_R X^2 + E_L X^2 = $\sqrt{\ }$ X ⇒ EA

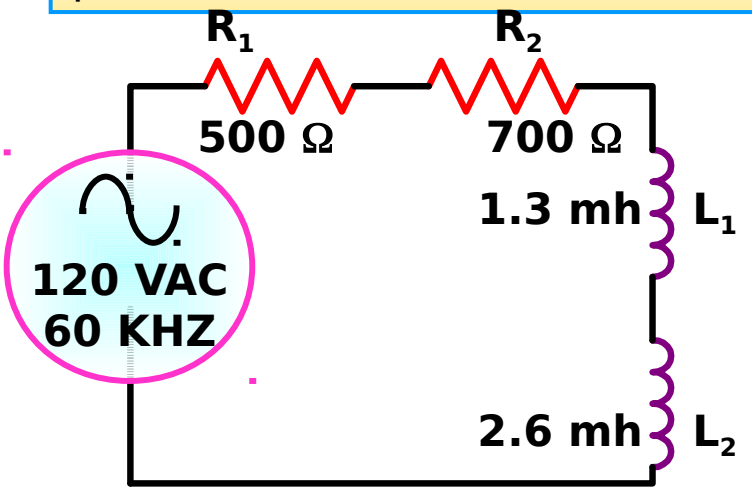


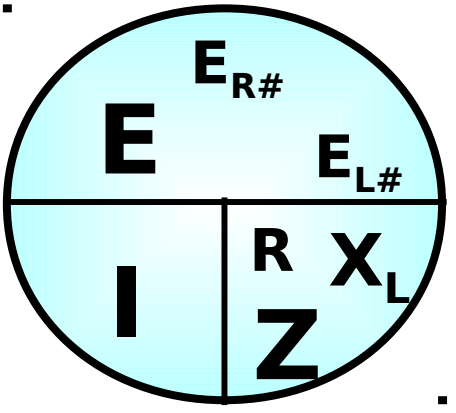
$EA =$	100 v	
$Z_T =$	50 Ω	$\sqrt{30^2 + 40^2}$
$I_T =$	2 A	$EA \div Z_T$
$E_{R1} =$	60 v	I_T X R_1
$E_{L1} =$	80 v	I_T X X_{L1}

60 X^2 + 80 X^2 = 10000 $\sqrt{\ }$ X ⇒ 100 v

AC: Inductive Ckt

Calculate; The Normal Operating Parameters.
[**No** Rounding, Decimal 3 places].





$2\pi F L_1 =$ $X_{L1} =$ _____

$2\pi F L_2 =$ $X_{L2} =$ _____

$2\pi F L_T =$ $X_{LT} =$ _____

$R_1 + R_2 =$ $R_T =$ _____

$\sqrt{R_T^2 + X_{LT}^2} =$ $Z_T =$ _____

$EA \div Z =$ $I_T =$ _____

$I_T \times R_1 =$ $E_{R1} =$ _____

$I_T \times R_2 =$ $E_{R2} =$ _____

$E_{R1} + E_{R2} =$ $E_{RT} =$ _____

$I_T \times X_{L1} =$ $E_{L1} =$ _____

$I_T \times X_{L2} =$ $E_{L2} =$ _____

$\sqrt{E L_1 + E L_2} =$ $E_{LT} =$ _____

$E_{RT}^2 + E_{LT}^2 =$ $EA =$ _____

Period = _____

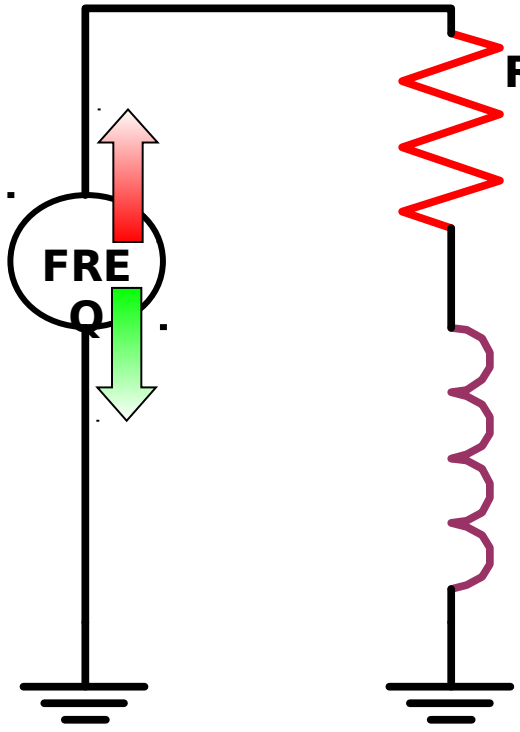
PW = _____

AC: Inductive Ckt.

Relationship;

As the <u>frequency</u> ⇑ the <u>XL</u> ⇑, if the <u>XL is</u> ⇑ then the <u>EL is</u> ⇑.

If the EL is ⇑, then the ER must ⇑. [Kirchhoff's law].



A <u>Direct</u> Relationship;

Exists between the Frequency, XL & EL .

An <u>Indirect</u> or Opposite relationship;

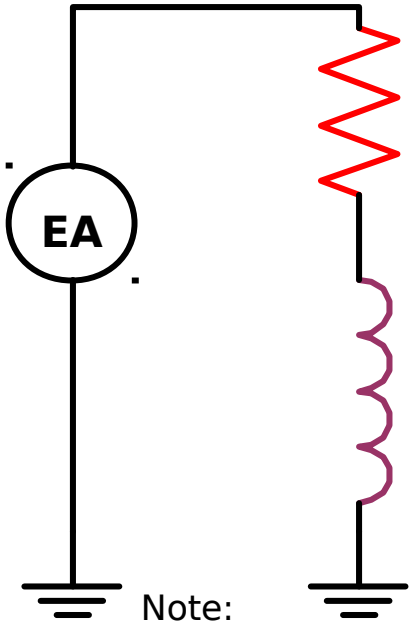
Exists between the EL& ER .

Impedance:

As Frequency ⇑, XL ⇑, Z ⇑ .

Resistance Remains unchanged.

OPENS & SHORTS:



OPEN

R_1 ⇑ = ∞ Ω , E_R ⇑ = EA , Z ⇑ = ∞

SHORT

R_1 ⇓ = 0 Ω , E_R ⇓ = 0 v , Z ⇓ = X_{L1}

OPEN

L_1 ⇑ = ∞ Ω , E_L ⇑ = EA , Z ⇑ = ∞

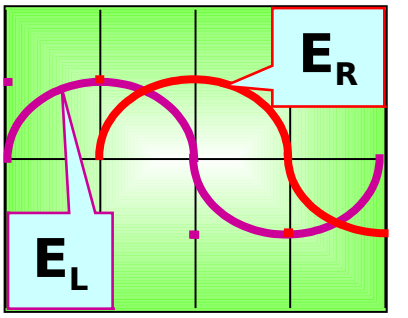
SHORT

L_1 ⇓ E_L ⇓ = 0 v , Z ⇓ = R_1

Note:
Actual Ohms Measurement will <u>normally</u> = **0** Ω, **Voltage Drop** is a valid Check.

AC: Inductive Ckt Concepts

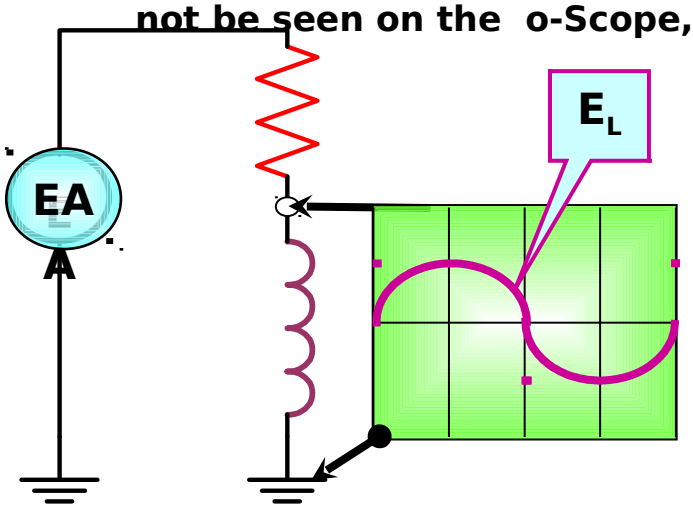
Phase Relationship;

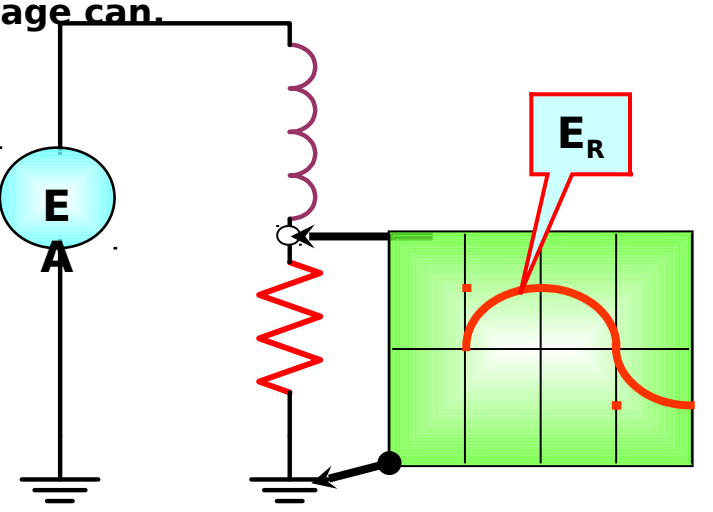


Observing the O-Scope w/a 2 channel setup.

All Measurements are made in reference to GND, when made w/the o-scope.

Point of reference is the voltage across a resistor, [I & ER are in phase]**. Current can not be seen on the o-Scope, voltage can.**





Problem Sheet;

1. The opposition to AC offered by an inductor is called ?

A. Inductive resistor

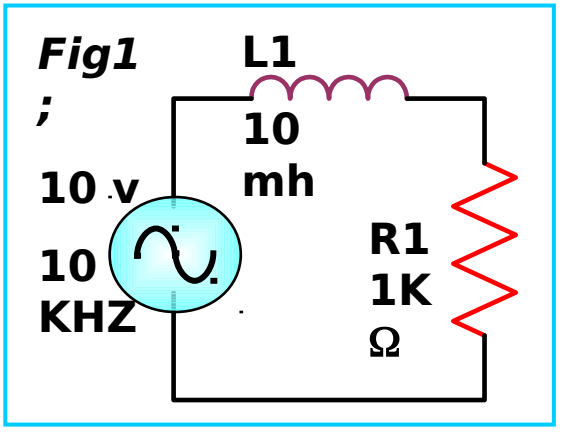
B. Resistance

C. Inductance

D. Inductive Reactance

2. What is the formula for computing inductive reactance? _____

3. Ref, *Fig 1*; Calculate Inductive Reactance. [XL] = _____



4. Ref, *Fig 1*; If R1 is shorted, what happens to the circuit Impedance?

A. Increase

B. Decrease the

C. Remains the same.

D. None of above.

Problem Sheet;

5. One type of core used in inductors is air, the other is ?

   A. Paper B. Gold C. Iron D. None of the above

6. Ref, *Fig 2;* What is the Applied Voltage? _____

7. Ref, *Fig 3;* Calculate the total inductance. _____

8. Ref, *Fig 3;* If L1 were to open, what would be the voltage across L2 ?

   A. Zero volts

   B. 5 VAC

   C. One half of EA

   D. 10 VAC

Fig; 2

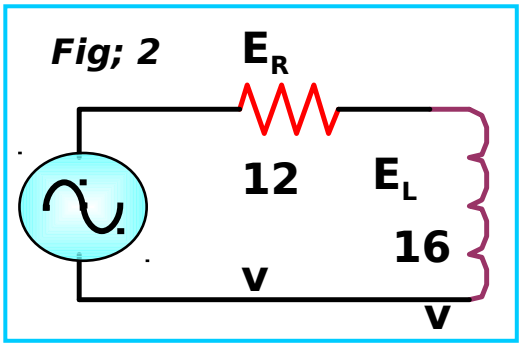
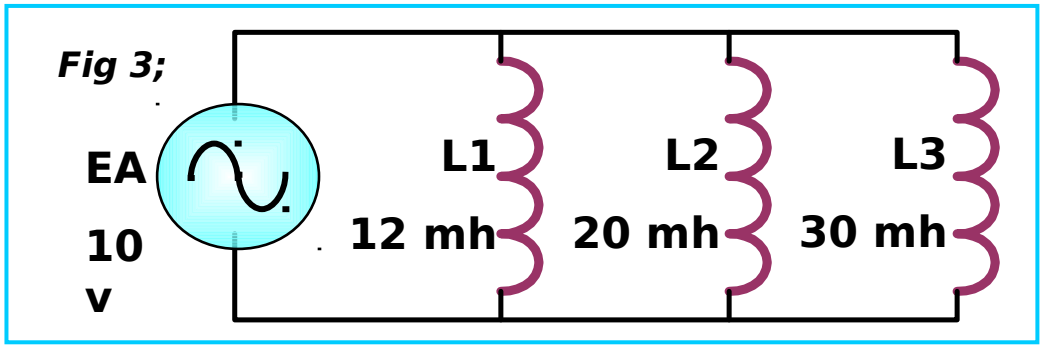


Fig 3;



9. Ref, *Fig 3;* If L1 is shorted, what happens to the voltage drop across L3 ?

   A. Increase

   B. Decrease

   C. Decrease, not to Zero

   D. Decrease, to Zero

10. Ref, *Fig 4*; Calculate the total inductance. _____

Fig; 4

AC: Inductive Ckt

Problem Sheet;

11. In an LR Ckt, [Inductor Resistor Ckt.] **the Current { *Leads* or *Lags* } the Inductor Voltage by { *180°* or *90°* } .**

12. Ref, *Fig 5*; Calculate the total inductance. _____

13. Ref, *Fig 5* ; If L1 is open, what happens to the voltage drop across L2 & L3?

A. 10 VAC **C. Zero volts**

B. One half of EA **D. 20 Volts**

14. Ref, *Fig 5;* L2 is open, what happens to the [XLT] ?

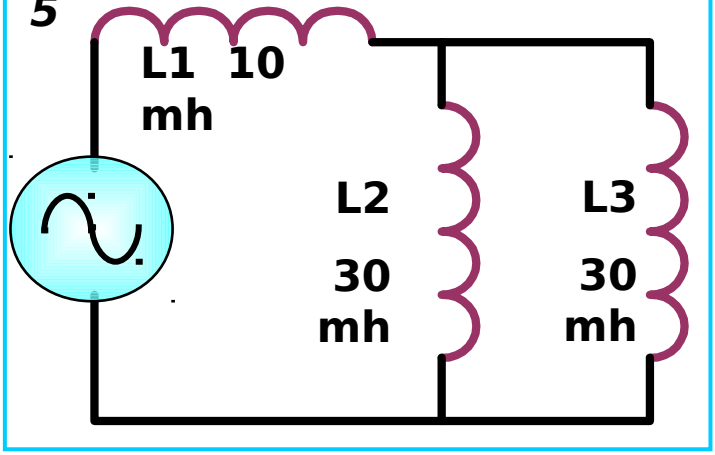
A. Remains the same **C. Decrease**

B. Increase **D. Not enough info**

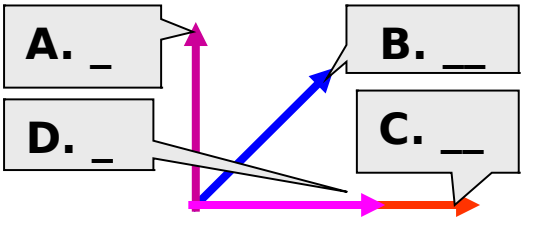
15. Label *Fig 6* as it refers to a series LR Ckt for I , ER, EL, EA.

16. What is the formula for calculating Impedance ? _____

Fig; 5



Fig; 6



Problem Sheet;

17. Ref, *Fig7*; Calculate the Impedance. Z = _____ .

18. Ref, *Fig 7*; Calculate the AC Current. I = EA ÷ Z I = _____

19. Ref, *Fig 7*; Calculate for E_R & E_L.

ER= IT X R1= _____ EL= IT X XL1= _____

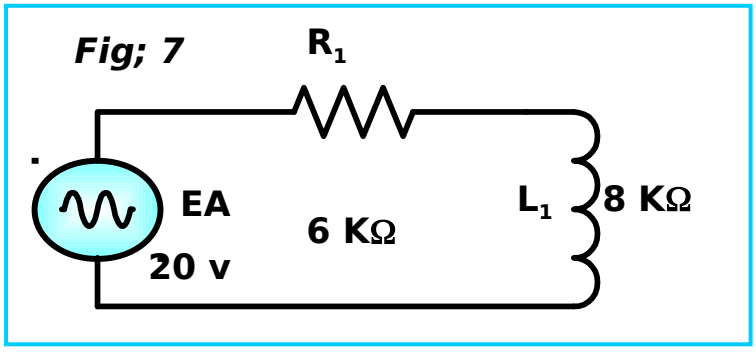
20. Ref, *Fig 7*; The applied frequency is increased. What effect does this have on Inductive Reactance [XL] ?

A. Increase

C. Decrease

B. Remains the same

D. Decreases EL



AC:

AC CAPACITIVE CIRCUITS

Unclassified

Safety & Environmental Impact is

“LOW”

In the previous lesson we dealt w/the Inductor, A component that is frequency sensitive. In this lesson we will look at the Capacitor. Its value of opposition will also change with the change in frequency.

The Capacitor is a reactive component & since its opposition cannot be measured it must be calculated.

AC: Capacitors Introduction

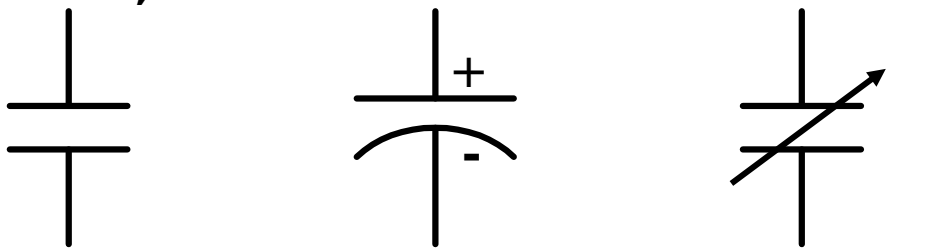
CAPACITOR {Cap}:

Opposes any <u>change in Voltage</u> & Stores energy in a Electrostatic Field. It <u>Blocks DC</u> & <u>Passes the Effects</u> of <u>AC</u>.

Schematic Letter Symbol; **C** **C_1** **C_2...**

Unit of Measure; **Farads,** **f** {lower case}, **fd ,** **μf** {micro farads},

Schematic Symbols;



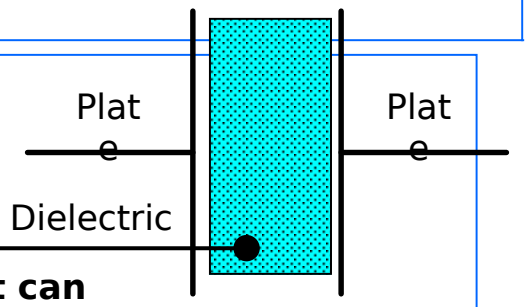
FIXED **ELECTROLYTIC** **VARIABLE**

CAP, Electrolytic;

Wiring integrity must be observed. The <u>Negative</u> side must be oriented <u>toward ground</u>.

The polarity is usually indicated on the case, or there is a black strip indicating the Negative lead.Wiring in reverse creates a Hazard.

CAP, 3 Basic Parts;



2 Plates.

Dielectric,

A solid, liquid or gaseous material that can sustain an Electrostatic Charge and act like an Insulator.

CAPACITANCE; **The Value of a capacitor is dependent on several factors.**

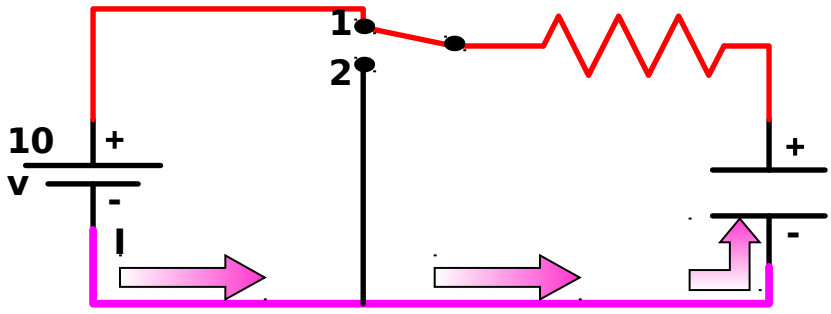
The <u>area of the plates</u>; [surface area]

<u>Distance between the Plates</u>; The greater the distance between the plates the less the capacitance, due to the effect of charged partials is less, as distance increases.

<u>Type of dielectric</u>; Air, Mica, Glass, Quartz, Castor oil, Vacuum. Provides the mathematical constant for the value of the Cap.

AC: Capacitors Concepts.

CAPACITOR, Charge & Discharge;

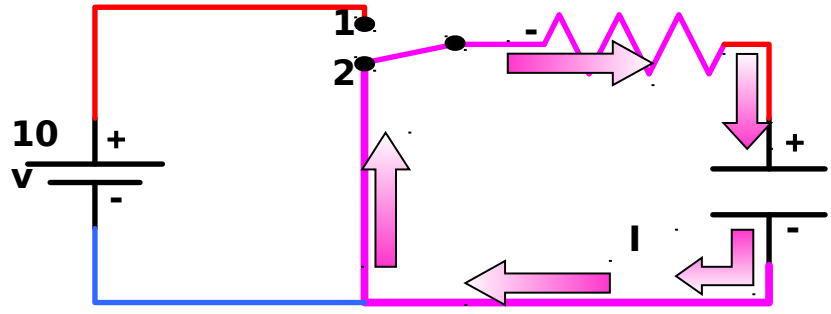


Charge path;

A Cap will only charge up to the Voltage Applied.

Current will flow to but not through A cap.

A Cap will hold a charge until a path is established for discharge.



Discharge path;

A Caps Discharge will leave in the opposite direction as it was charged.

Current will flow to the most positive point in the Ckt.

CAPACITOR, CT;

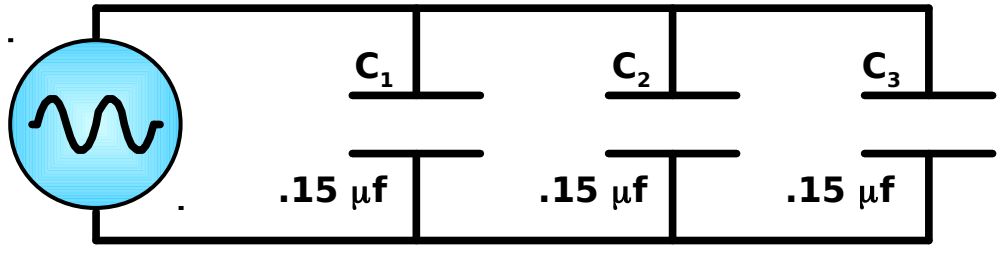
Calculating for CT;

The objective is to reduce the capacitor value down to a single value of Capacitance { C_T }.

Capacitors in Parallel;

Are calculated like Resistors in series. $C_1 + C_2 + C_3 ... = C_{EQ}$.

This is due to the surface area of the plates acting as 1 Capacitor.



Note:

CEQ & CT are the same in a pure Parallel Ckt.

$C_1 + C_2 + C_3 ... = C_{EQ}$

.15µf + .15µf + .15µf = .45µf

AC: Capacitors CT.

Capacitors in Series;

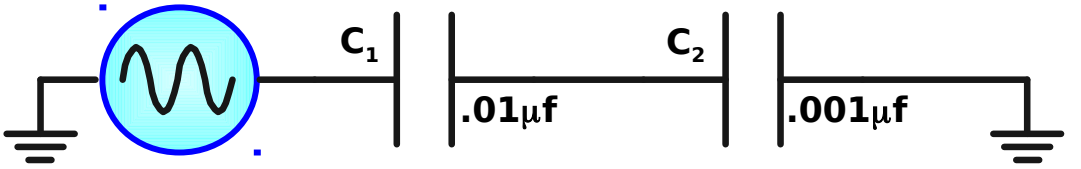
Are calculated <u>like Resistors in Parallel</u>.

This is due to the area between the plates.

Like Value, Product over the Sum, Reciprocal.

C_T will be smaller than the smallest Cap.

$$C_1\ 1/X + C_2\ \ 1/X = 1/X \Rightarrow C_T.$$



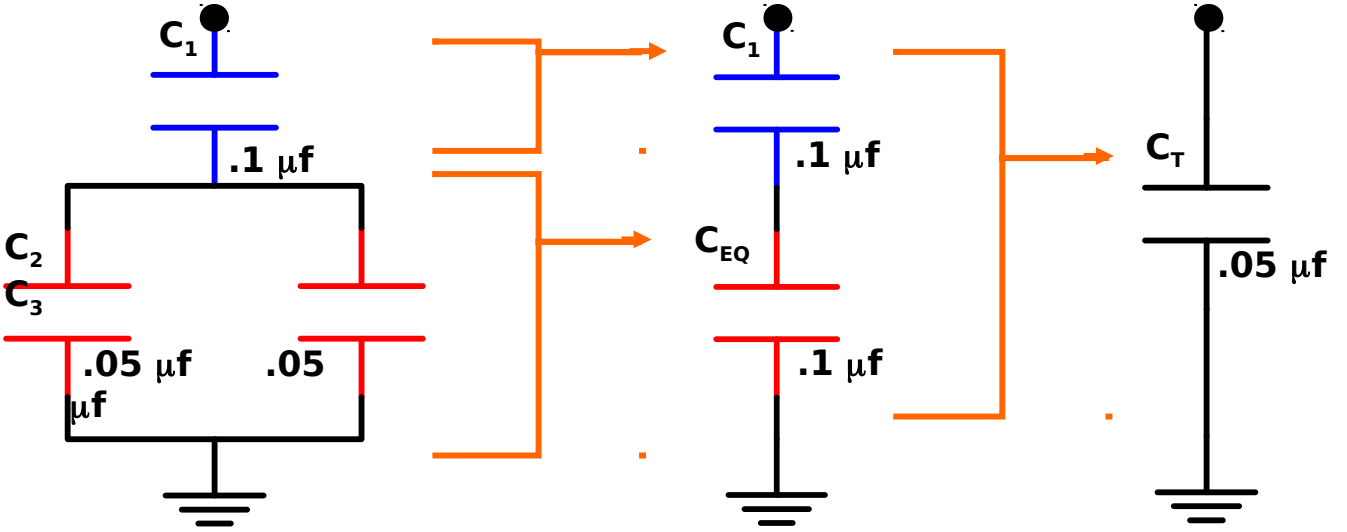
.01μf 1/X + .001 μf 1/X = 1/X ⇒ .0009 μf

Capacitors in Series & Parallel;

The <u>Series portion</u> is calculated <u>Like Resistors in Parallel</u>.

The <u>Parallel portion</u> is calculated <u>Like Resistors in Series</u>.

The Reduction of the Parallel puts the Caps in Series, therefore they must be calculated like resistors in Parallel, to acquire a single value of capacitance, { CT }.



AC: Capacitors XC & Relationship.

Capacitive Reactance;

Capacitors like Inductors are a frequency sensitive devices. Since their opposition cannot be measured it must be calculated, w/ Frequency as part of the equation.

1 Over, 2 Pies For Chow

$$\frac{1}{2\pi F C} = XC \text{ in } \Omega$$

6.28 X Frequency X Capacitor 1/X ⇒ XC

6.28 X 10 KHz X .001μf 1/X ⇒ 15.923 KΩ

On the Calculator:

6.28 X 10 EE 3 X .001 EE -6 = 1/X ⇒ 15923. = 15.9KΩ

Calculate Capacitive Reactance XC; 3 places, NO Rounding.

Freq = 6 KHz	**Cap = 3 μf**	**X_c = _____**
Freq = 8 KHz	**Cap = 3 μf**	**X_c = _____**
Freq = 10 KHz	**Cap = 3 μf**	**X_c = _____**

$$\frac{1}{2\pi F C} = X_c \text{ in } \Omega$$

Freq = 10 KHz	**Cap = 4 μf**	**X_c = _____**
Freq = 10 KHz	**Cap = 8 μf**	**X_c = _____**
Freq = 10 KHz	**Cap = 10 μf**	**X_c = _____**

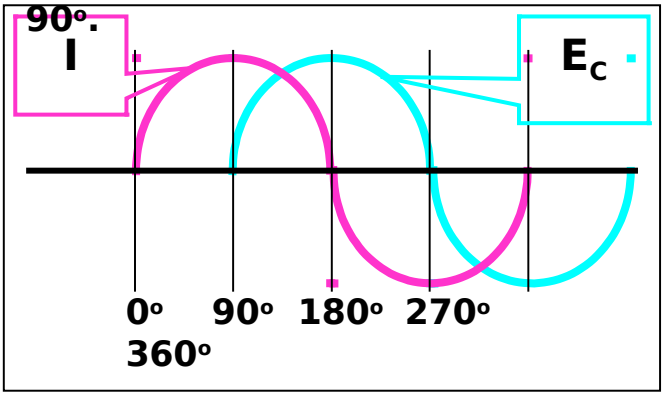
AC: Capacitors Phase Relationship & Impedance.

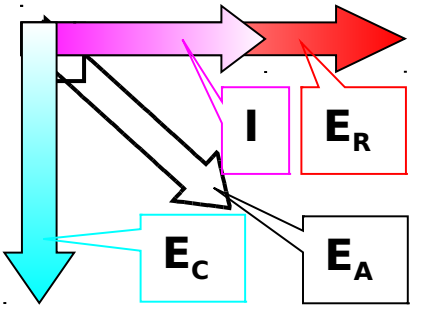
Phase Relationship;

Current leads Voltage by 90°

Eli the I C E man is 90 years old

SINE; 90° out of Phase; I Current leads Voltage in a Capacitor EC, by 90°.





Vector; 90° out of Phase;

I Current leads Voltage in a Capacitor EC, by 90°.

Impedance {Z}; **The total opposition to AC.**

A Ckt of Resistors & Capacitors [non-reactive] & [reactive] **the total opposition must be added using Vector Addition.**

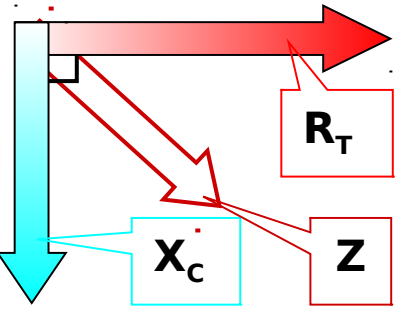
Z

Ω

$$Z = \sqrt{R_T^2 + X_{CT}^2}$$

On the Calculator:

R X^2 **+ XC** X^2 **=** $\sqrt{x}$ ⇒ **Z** in Ω

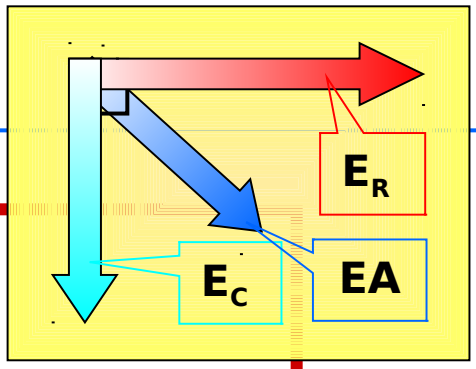


Once Impedance has been accomplished, all other operating parameters in a Ckt can be calculated.

AC: Capacitors, Applied Voltage.

Applied Voltage; {EA};

Because the opposition was added using Vector Addition the Voltage Applied will also have to be added the same way.



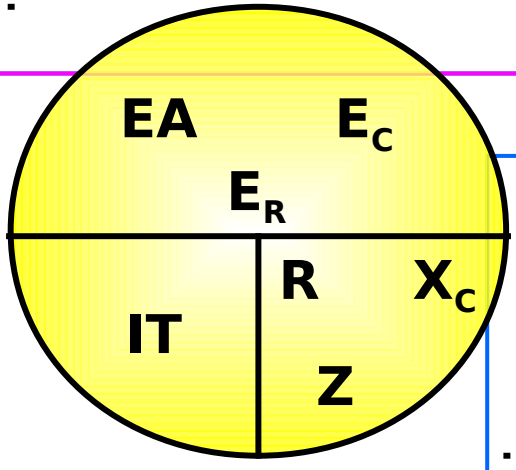
$$EA = \sqrt{E_{RT}^2 + E_{CT}^2}$$

On the Calculator:

E_{RT} X^2 + E_{CT} X^2 = $\sqrt{X}$ ⇒ EA

Calculating the Operating parameters; Sequence.

$$\frac{1}{2\pi F C} = X_C \text{ in } \Omega$$



- C_{EQ}
- C_T
- R_T
- $X_{C\#}$
- X_{CT}
- Z
- I_T
- $E_{R\#}$
- E_{RT}
- $E_{C\#}$
- E_{CT}
- EA

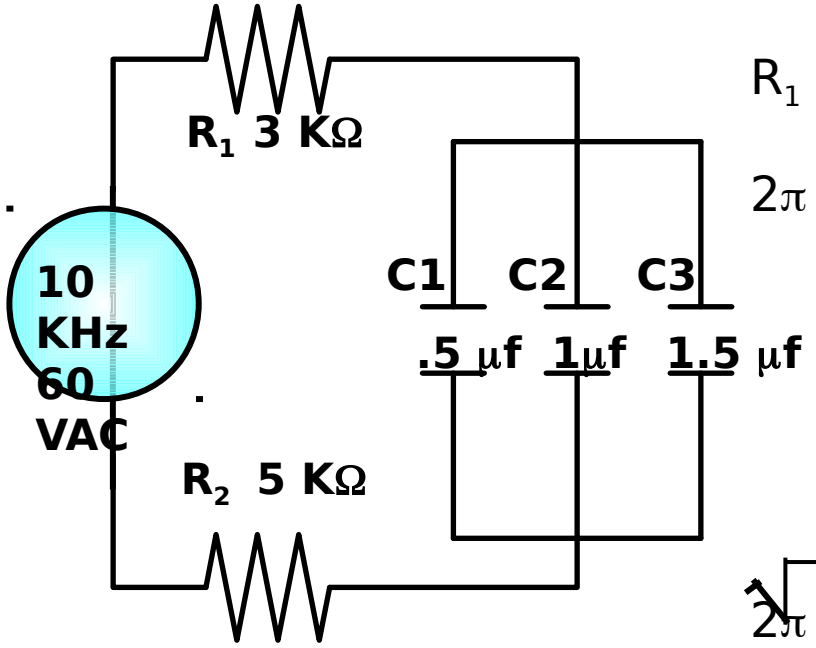
$$Z = \sqrt{R_T^2 + X_{CT}^2}$$

$$EA = \sqrt{E_{RT}^2 + E_{CT}^2}$$

AC: Capacitors, Concepts.

Calculate Operating parameters; 3 Places,

No Rounding.



$C_1 + C_2 + C_3 =$ **C_T** _____

$R_1 + R_2 =$ **R_T** _____

$2\pi F C_1 = 1/X \Rightarrow$ **X_{C1}** _____

C_2 _____

X_{C2} _____

C_3 **X_{C3}** _____

$\sqrt{\quad}$

$2\pi F C_T = 1/X \Rightarrow$ **X_{CT}** _____

$R_T^2 + X_{CT}^2 =$ **Z** _____

$I_T \times R_1 =$ **E_{R1}** _____

$EA / Z =$ **I_T** _____

$I_T \times R_2 =$ **E_{R2}** _____

$I_T \times R_T =$ **E_{RT}** _____

$I_T \times X_{CT} =$ **E_{C1}** _____

$I_T \times X_{CT} =$ **E_{C2}** _____

$I_T \times X_{CT} =$ **E_{C3}** _____

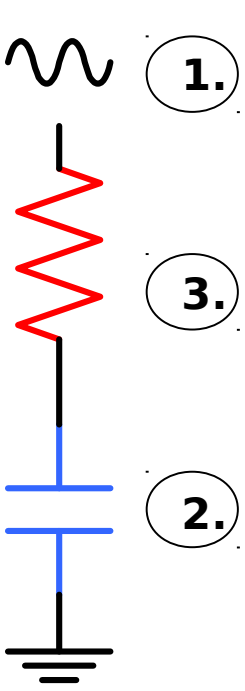
$\sqrt{\quad}$

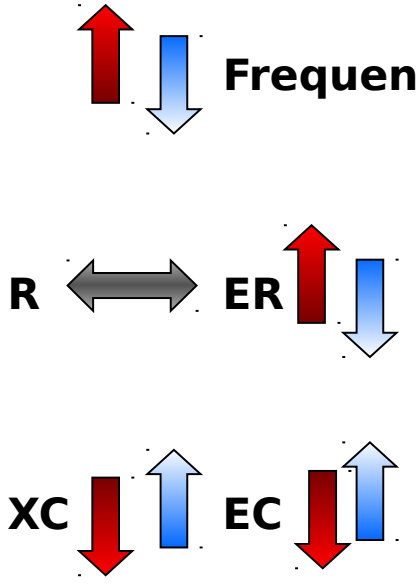
$I_T \times X_{CEQ} =$ **E_{CEQ}** _____

$E_{RT}^2 + E_{CEQ}^2 =$ **EA** _____

AC: Capacitors, Concepts.

Relationship; RC type Ckt,





IF the Frequency ▯ the XC ▯ so the Voltage Drop of the cap [EC] ▯ .

If the EC is ▯ Kirchhoff's law dictates that the Voltage Drop of the resistor ER must ▯ .

The inverse is true if the Freq Decreases.

Bench test a Cap; Ohms Check.

A cap placed w/in the Ckt cannot be checked using an Ohms setting. Removing the Cap from the Ckt it can be checked.

3 conditions of a defective Cap; OPEN, SHORT, RESISTIVE.

while to

NORMAL; **Place the leads across the cap & reverse watching the meter, the meter should go Zero then return to Infinity.**

OPEN; **Will stay at infinity in both directions.**

SHORT; **Will read Zero in both directions.**

RESISTIVE; **Will read resistive in both directions.**

In a later lesson Signal analysis will be introduced, a method of checking a Cap with in the Ckt.

AC: Capacitors, Problem Sheets.

1. **The opposition to AC offered by a Capacitor is called ?**

   A. Impedance **C. Capacitance**

   B. Resistance **D. Capacitive Reactance**

2. **What is the formula for computing capacitive reactance ?**

   _____

3. **Refer to *Fig 1;* Calculate the Capacitive Reactance** [XC]**.**

   _____

4. **Refer to *Fig 1;* If R1 is shorted, what would happen to ckt Impedance ?** _____

5. **Refer to *Fig 1;* Calculate [Z] for the Ckt.** _____

6. **Refer to *Fig 1;* Calculate [IT] for the Ckt.** _____

7. **Refer to *Fig 2;* Calculate CT for the Ckt.** _____

8. **By how many degrees does the current { LEAD** or **LAG } the Voltage over a Cap ?** _____

9. **If the ER = 12 V and EC = 16 V, what is EA?** _____

10. **If R = 6 KΩ & XC = 8 KΩ , what is Z ?** _____

11. **If the applied <u>Frequency is Increased</u> in a capacitive circuit what would happen to the <u>XC</u> ?** _____

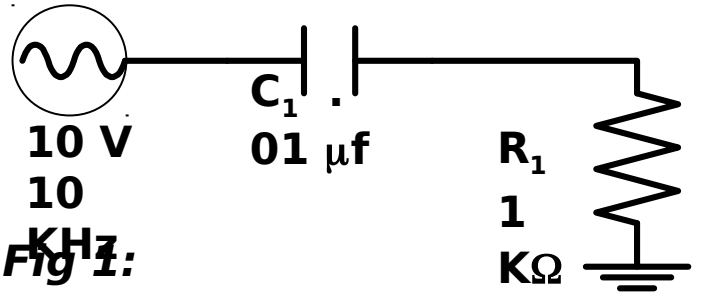
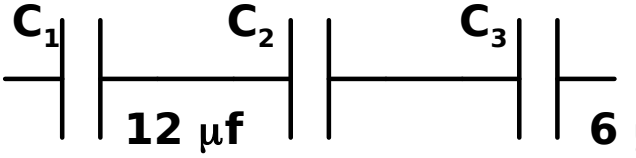


Fig 1:

Fig 2:



12 μf

12. Refer to ***Fig 3*** ; Calculate Total Capacitance. _____

13. Refer to ***Fig 3*** ; If C1 were to open, what would be the Voltage across C2 ? _____

14. Refer to ***Fig 3*** ; If C2 were to Short, what would be the Voltage across C1 ? _____

15. Refer to ***Fig 4*** ; Calculate CT. _____

Fig 3:

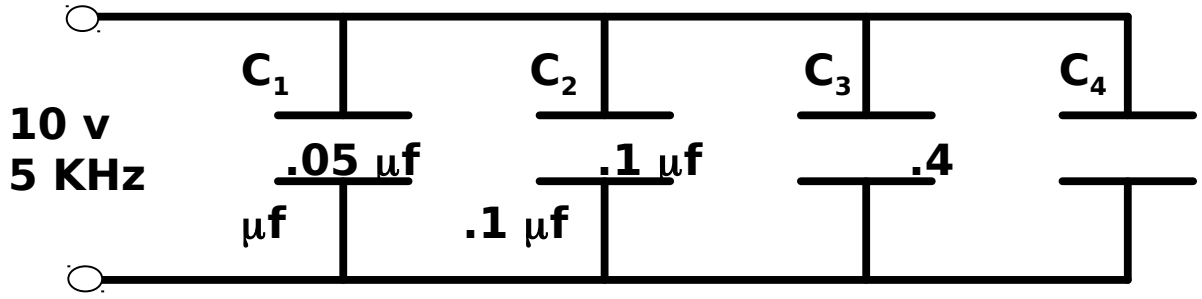
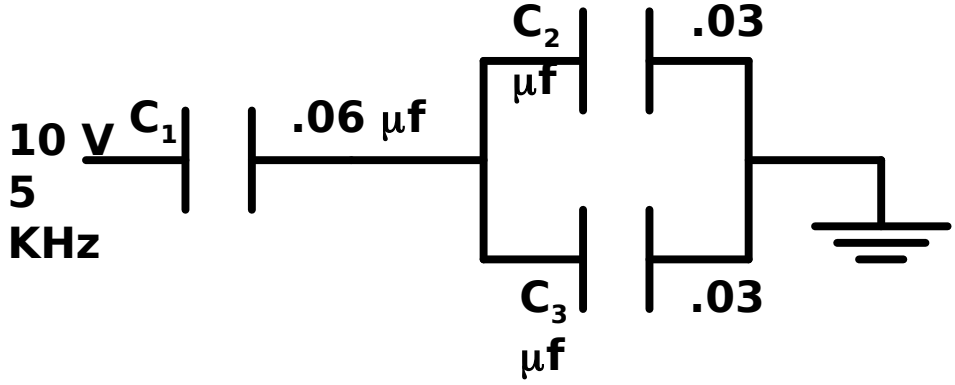


***Fig 4*:**



AC: Capacitors, Problem Sheets.

16. Refer to *Fig 4;* What would cause the XC to INCREASE ?

A. Increasing Freq

B. Short C2

D. Both A. & B.

C. Open C3

17. Refer to Fig 4; What would cause the XC to DECREASE ?

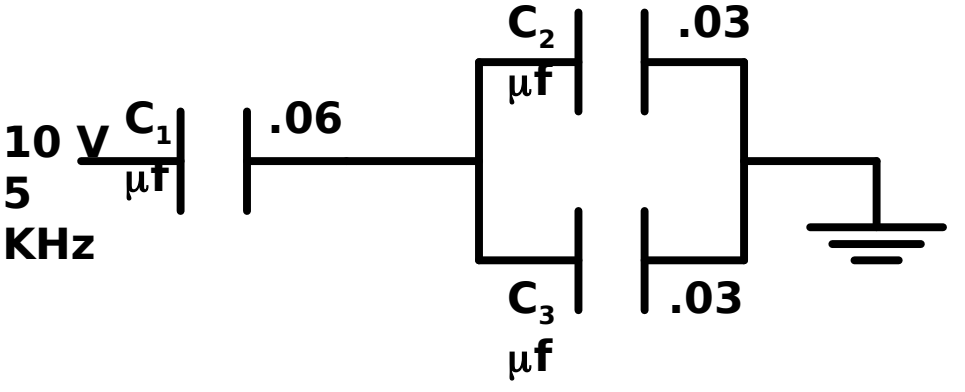
A. Decrease Freq

B. Short C3

C. Open C3

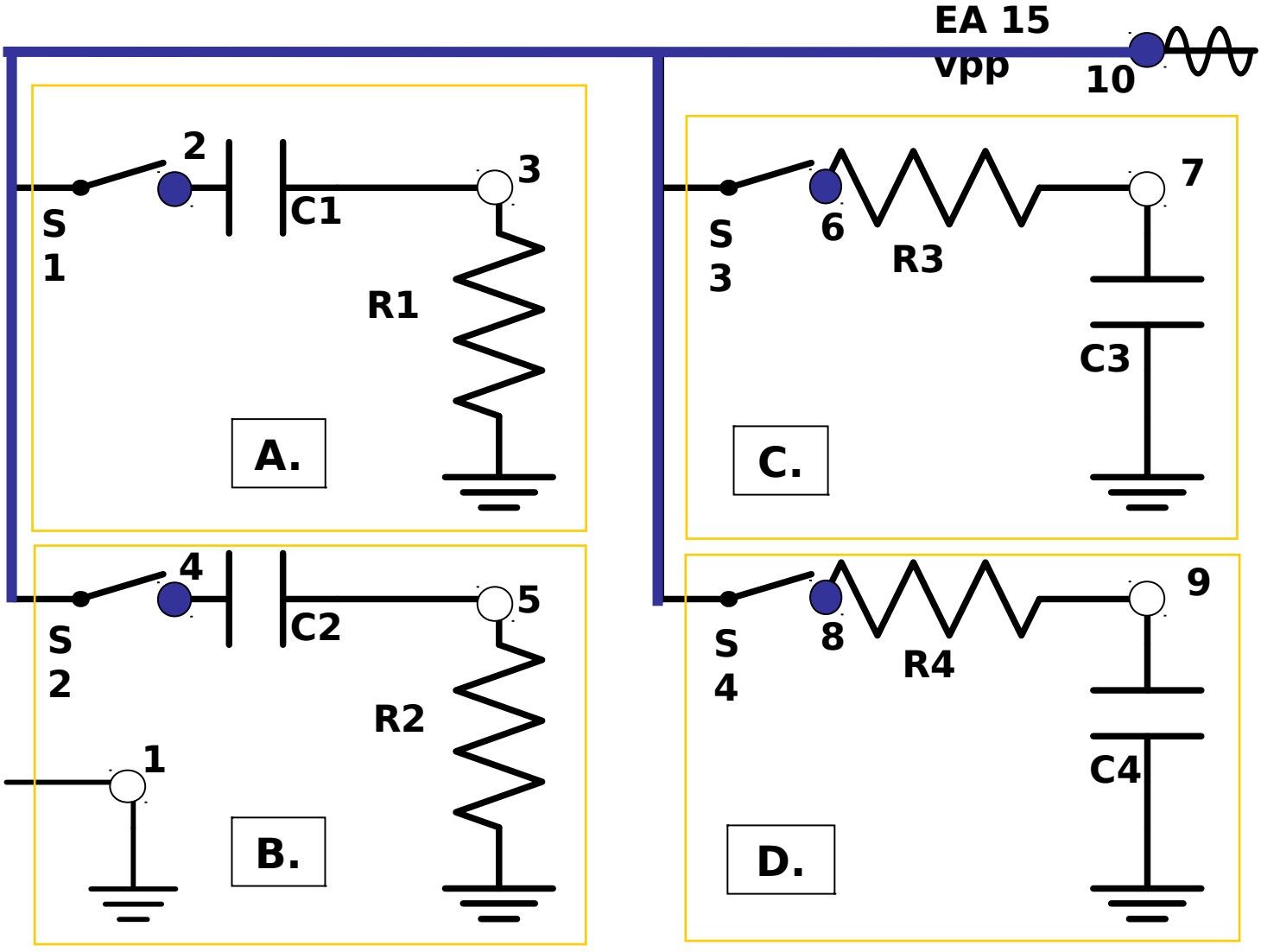
D. Both A. & B.

***Fig 4*:**



AC: Capacitors, PE Ckt Card.

Note: 4 Ckt's & EA on each Ckt.



Note: Reference this figure for the next two slides.

Voltage Measurements; RMS W/ DMM

ER# or EC# are voltage drop measurements. The TP on each side of the component is used to take the measurement.

ETP; Like the voltages @ test-points in DC, every component between the Probe placement & Gnd is the sum of the voltage drops from each component.

Voltage Measurements; P-P with the O-Scope.

All measurements made w/ the O-Scope are made in reference to ground, like the voltages @ test-points in DC. Every component between the Probe placement & Gnd is the sum of the voltage drops from each component.

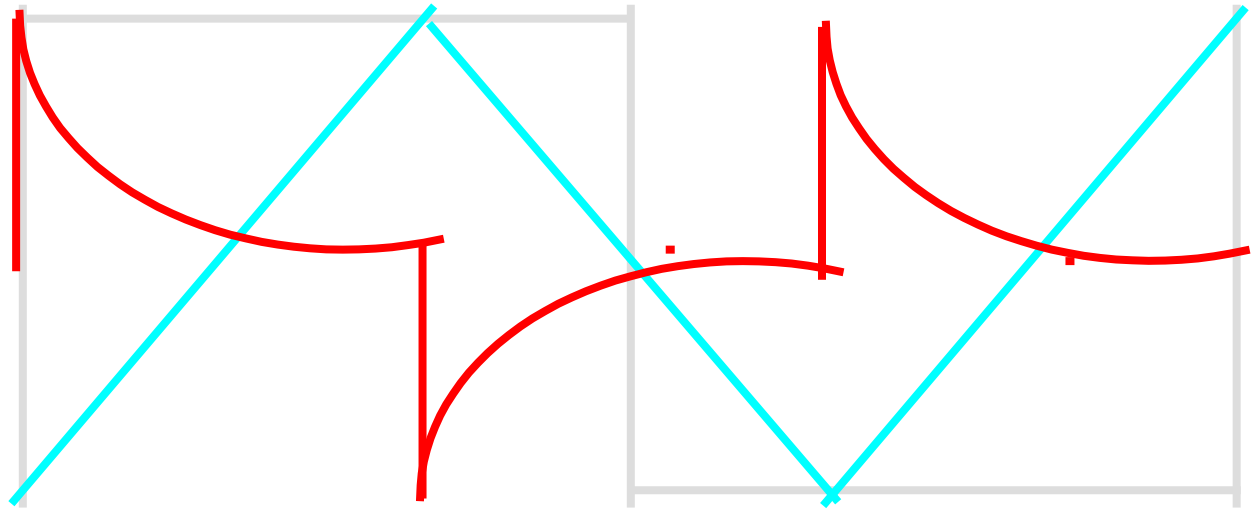
SLIDE; 32, 33, 34

AC:

Transients in RC Circuits

UNCLASSIFIED;

Safety & Environmental Impact; LOW



This lesson will enable you to determine what type of ckt is being used based upon the size of the Resistor & Capacitor which will change the input waveform to a distinctly different waveform at the output.

These circuits are use extensively in private & defense electronics, for timing devices.

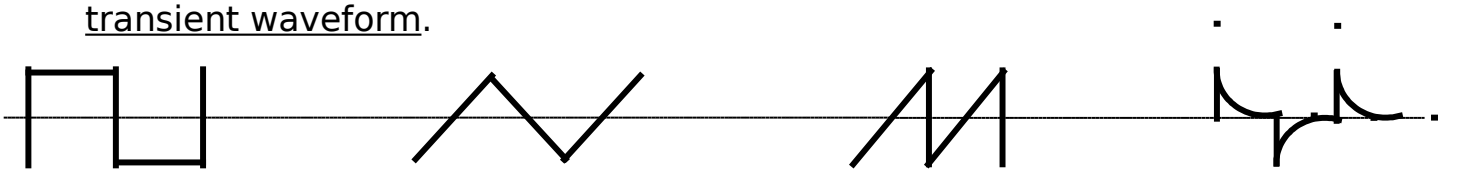
AC: Transients in RC Circuits.

RC Ckt;

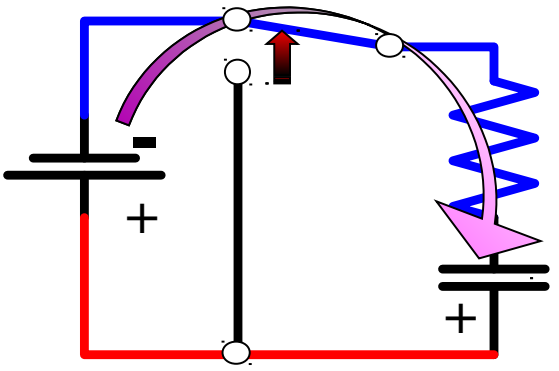
A Ckt comprising of a Resistor & Capacitor in series where the rate [time] of Charge & Discharge is dictated by the value [size] of the Resistor & Cap.

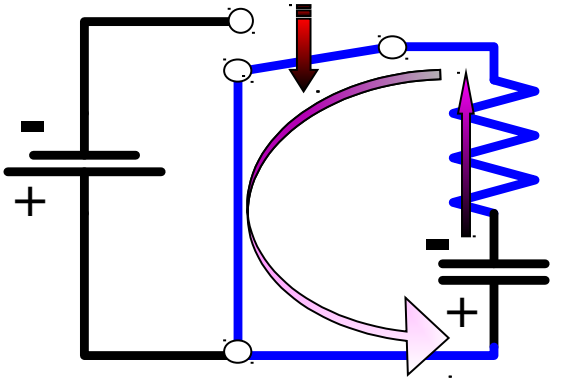
Transient Waveform;

A waveform that changes from one steady state to another or is positive for a period of time, then Negative for an equal period of time. A Sine wave is not a transient waveform.



Square **Triangular** **Saw tooth** **Spike**





Time Constant;

The rate [time] of Charge & Discharge dictated by the value [size] of the Resistor & Cap is called the TIME CONSTANT.

The **TC** is measured in units of Seconds, Expressed in μ **Sec** only.

1 Time Constant [TC] is the amount of time required for a Capacitor to charge to 63% of the Applied voltage.

TC = R X C in Micro Seconds

R= 10KΩ C = .001μf

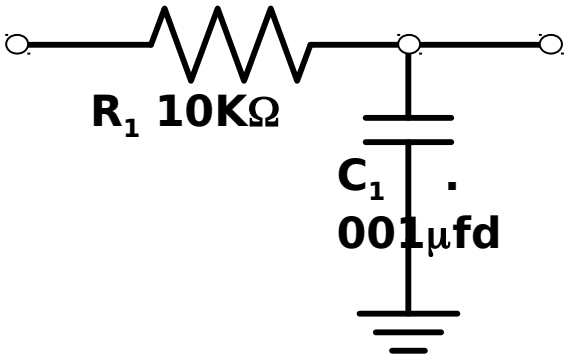
$10\ EE^{3} \times .001\ EE^{-6} = .00001$ Sec = 10μS

Move the decimal 6 places .0000 10.

On the calculator; 2^{nd} Function 6 ⇒ 10^{-6}

AC: Transients in RC Circuits.

Calculate the TC for the following Ckt values.



TC = R X C

$10\ EE^{3}\ X\ .001\ EE^{-6} = .00001$

⇒ TC =10 μSec

R = 5 KΩ	C = .001 μf	TC = _____
R = 10 KΩ	C = .001 μf	TC = _____
R = 1 KΩ	C = . 1 μf	TC = _____
R = 20 KΩ	C = .01 μf	TC = _____
R = 10 KΩ	C = .01 μf	TC = _____

1 TC = 63%

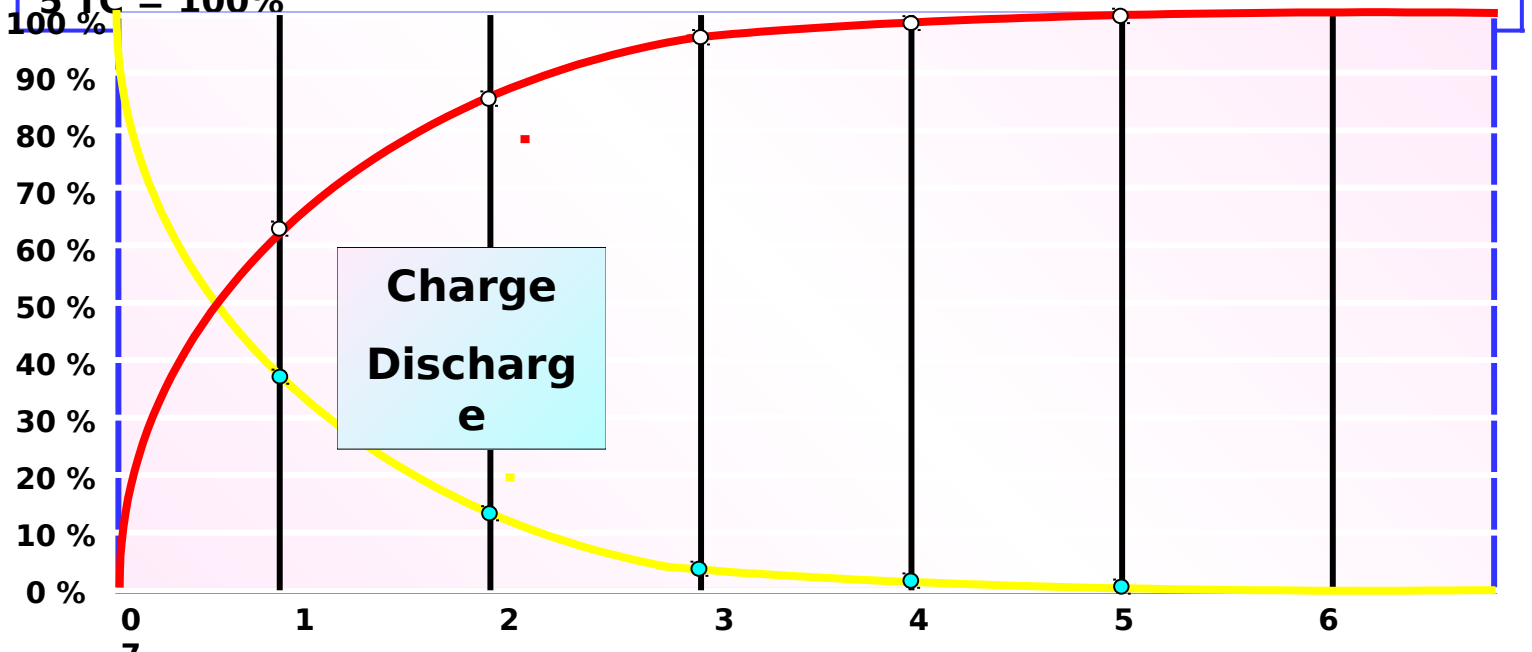
Chart;

4 TC = 37%

5 TC = 100%

Time Constant

Reference, White Government Tng Aid.



AC: Transients in RC Circuits, Problem Sheet & PW.

JOB 1; **Calculate the TC for the following problems.**
All answers must be in μS .

a.	**R = 10 KΩ**	**C = 1 μf**	**TC = _____**
b.	**R = 5 KΩ**	**C = 5 μf**	**TC = _____**
c.	**R = 100 Ω**	**C = .5 μf**	**TC = _____**
d.	**R = 1 KΩ**	**C = 1 μf**	**TC = _____**
e.	**R = 100 KΩ**	**C = 100 μf**	**TC = _____**
f.	**R = 500 Ω**	**C = 1 μf**	**TC = _____**
g.	**R = 20 KΩ**	**C = 100 μf**	**TC = _____**
h.	**R = 50 KΩ**	**C = .01 μf**	**TC = _____**
i.	**R = 50 Ω**	**C = .1 μf**	**TC = _____**
j.	**R = 10 MΩ**	**C = 3 μf**	**TC = _____**

Pulse Width;

$$PW = \frac{1}{2\ F} \qquad PW = \frac{1}{2 \times Freq}$$

On the Calculator;

Frequency = 50 KHz

50 EE³ X 2 = 1/X ⇒ .00001 Sec

PW = .0000 10. μS

W/ 2nd Function Key; **$PW = 10^{-6}$**

PW Must be in **μS**

1 KHz	**PW = _____**
5 KHz	**PW = _____**
10 KHz	**PW = _____**
20 KHz	**PW = _____**
50 KHz	**PW = _____**

AC: Transients in RC Circuits, Problem Sheet.

JOB 2; Calculate the PW of the following Frequencies.

a.	**F = 1 KHz**	**PW = _____**
b.	**F = 100 Hz**	**PW = _____**
c.	**F = 55 KHz**	**PW = _____**
d.	**F = 100 KHz**	**PW = _____**
e.	**F = 1 MHz**	**PW = _____**
f.	**F = 60 KHz**	**PW = _____**
g.	**F = 10 KHz**	**PW = _____**
h.	**F = 1000 Hz**	**PW = _____**
i.	**F = 5 KHz**	**PW = _____**
j.	**F = 25 KHz**	**PW = _____**

AC: Transients in RC Circuits, TC / PW Ratio.

TC to PW Ratio;

$$\frac{\text{TC}}{\text{PW}} = \frac{\text{Time Needed}}{\text{Time Have}}$$

The TC tells us how much time is NEEDED to charge a Capacitor 63% of the Applied Voltage.

The PW tell us how much time we have to charge a Capacitor to 63% of EA.

Reduce the Fraction;

$$\frac{\text{TC} = 10\ \mu\text{S}}{\text{PW} = 100\ \mu\text{S}} \Rightarrow \frac{10}{100} \Rightarrow \frac{1}{10}$$

Strike out the common 0

Reduce the Fraction;

$$\frac{10\ \mu\text{S}}{100\ \mu\text{S}} \Rightarrow \frac{1}{10}$$

10 will go into 100, 10 times

$$\frac{10\ \mu\text{S}}{100\ \mu\text{S}} \Rightarrow \frac{1}{10}$$

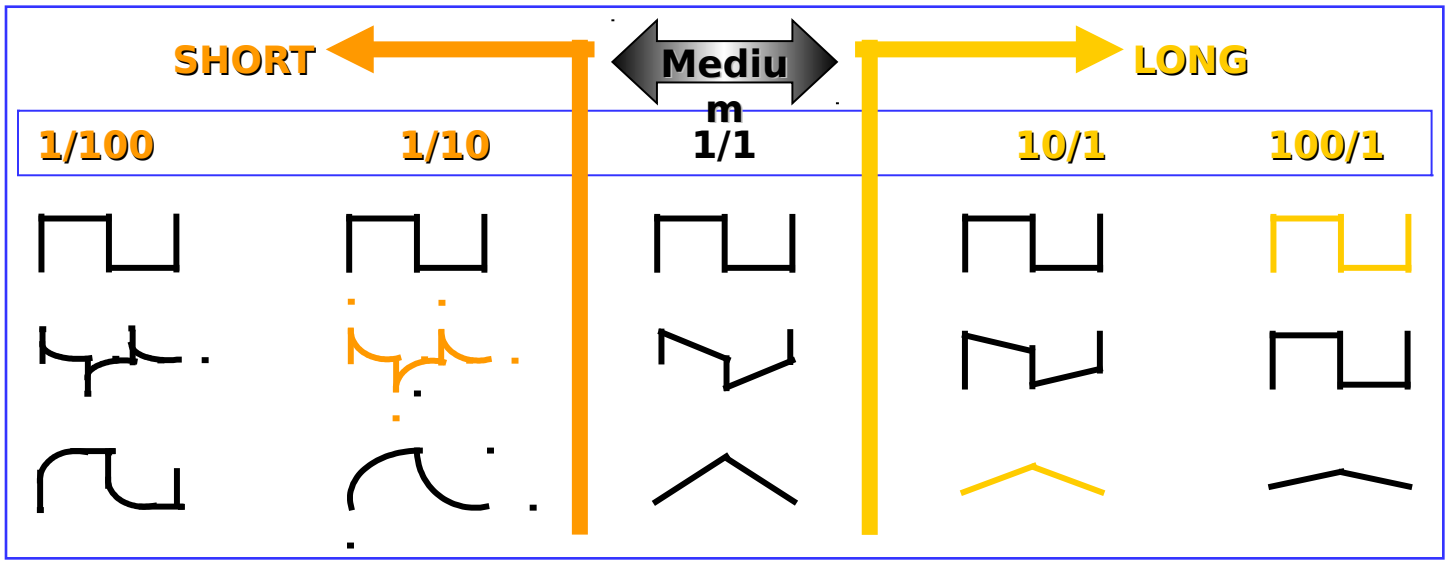
10 will go into 10, 1 time

Note: All fractions must be reduced to the lowest term of 1/# or #/1

$\frac{\text{TC}}{\text{PW}} = \frac{\text{Time Needed}}{\text{Time Have}}$	[< Or =]	$\frac{1}{10}$	**Short** Plenty of time to Charge the Cap
$\frac{\text{TC}}{\text{PW}} = \frac{\text{Time Needed}}{\text{Time Have}}$	[≥]	$\frac{10}{1}$	**Long** Does not allow the Cap to fully charge.
$\frac{\text{TC}}{\text{PW}} = \frac{\text{Time Needed}}{\text{Time Have}}$	[=]	$\frac{1}{1}$	**Medium** Use in the lesson today. No practical application.

AC: Transients in RC Circuits.

TC to PW Chart; Reference White Gov Tng Aid.



Challenge Problem;

Calculate the TC/PW Ratio & Identify if it is Short Medium or Long.

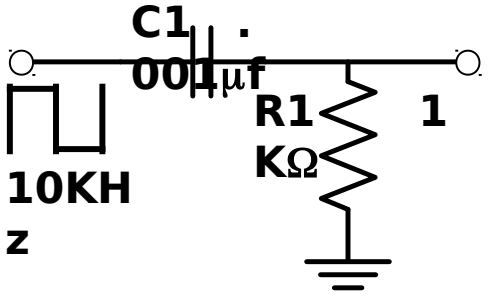
TC = 10 μS	**PW = 200 μS**	**TC/PW =_____**
TC = 50 μS	**PW = 50 μS**	**TC/PW =_____**
TC = 100 μS	**PW = 10 μS**	**TC/PW =_____**
TC = 25 μS	**PW = 100 μS**	**TC/PW =_____**
TC = 60 μS	**PW = 600 μS**	**TC/PW =_____**

AC: Transients in RC Circuits, Problem Sheet.

JOB 3;

Calculate the TC/PW, Ratio & Identify as Short Medium or Long.

a.



TC: _____

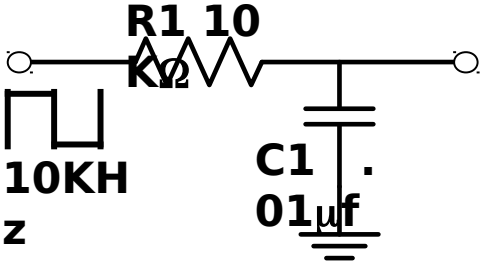
PW: _____

Ratio: _____

Identify: _____

---

b.



TC: _____

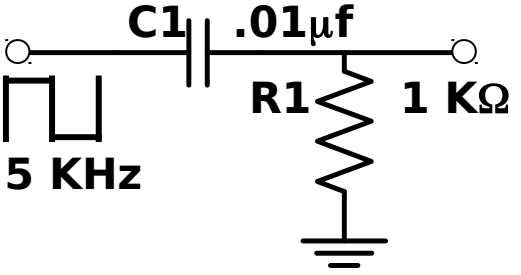
PW: _____

Ratio: _____

Identify: _____

---

c.



TC: _____

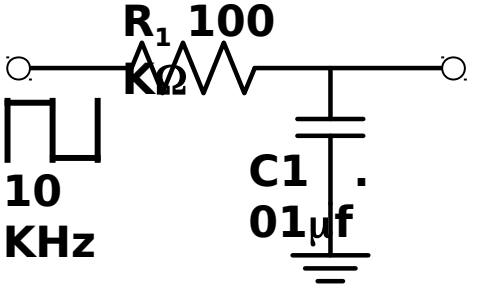
PW: _____

Ratio: _____

Identify: _____

---

d.



TC: _____

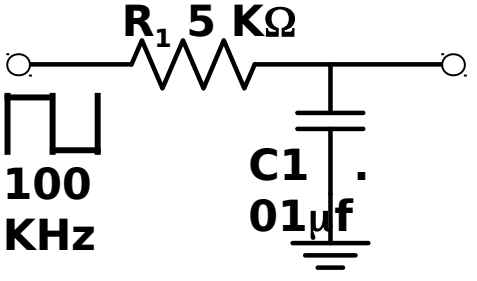
PW: _____

Ratio: _____

Identify: _____

---

e.



TC: _____

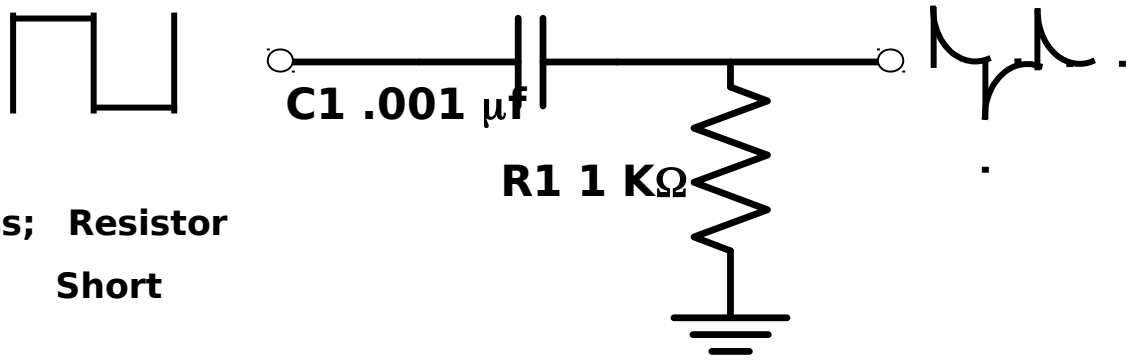
PW: _____

Ratio: _____

Identify: _____

AC: Transients in RC Circuits.

Differentiator;

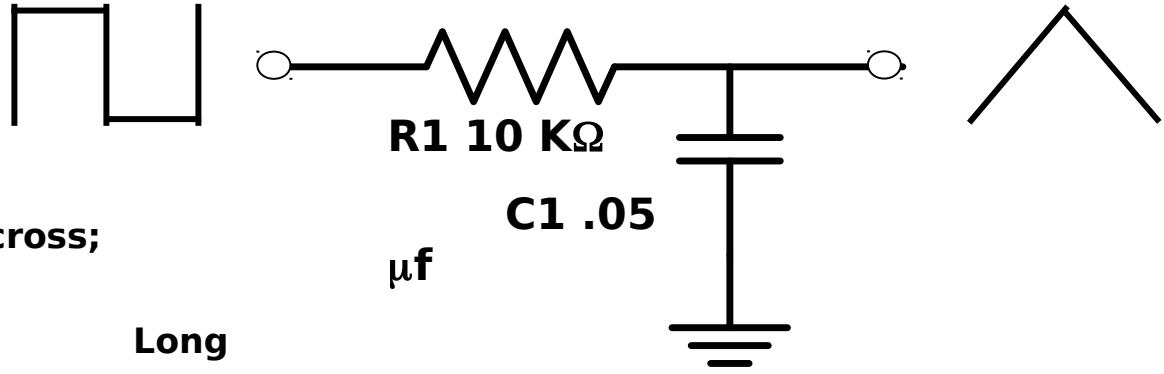


Output taken across; Resistor

TC/PW ; Short

Output waveform; Spiked

Integrator;



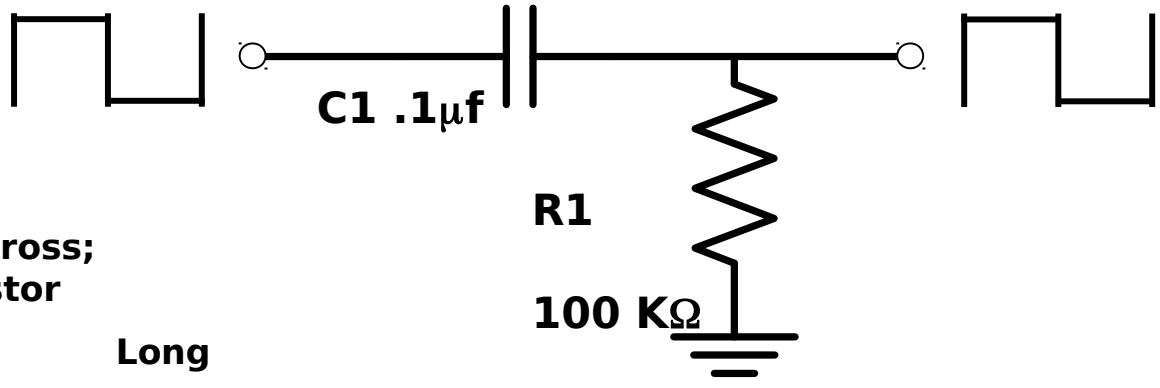
Output taken across; Capacitor

TC/PW ; Long

Output waveform; Triangular

Note: the Integrator is unique in the fact that it is the only one of the three Ckts that the output is taken across the Capacitor, in reference to Gnd.

Coupler;



Output taken across; Resistor

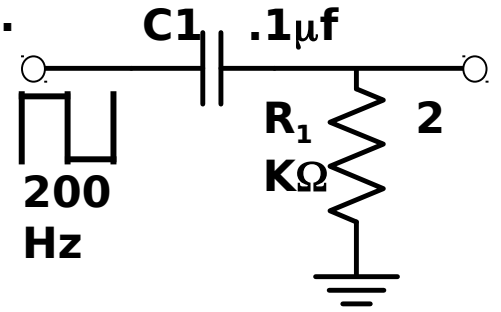
TC/PW ; Long

Output waveform; Square

AC: Transients in RC Circuits, Problem Sheet.

JOB 4: **Calculate** the TC/PW Ratio & Name the Ckt.

a.



Output Component: _____

TC: _____

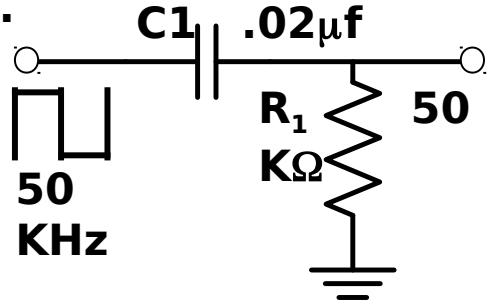
PW: _____

Ratio: _____

Name Ckt: _____

---

b.



Output Component: _____

TC: _____

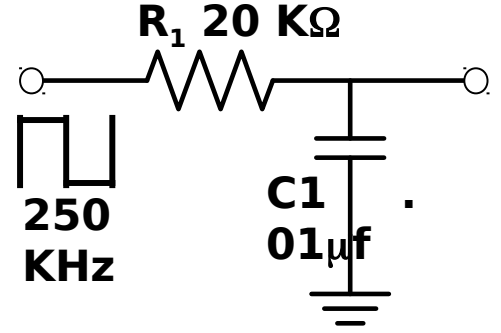
PW: _____

Ratio: _____

Name Ckt: _____

---

c.



Output Component: _____

TC: _____

PW: _____

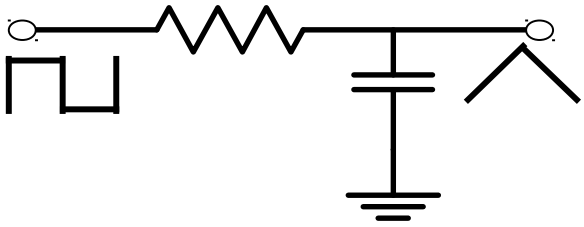
Ratio: _____

Name Ckt: _____

AC: Transients in RC Circuits, Problem Sheet.

JOB 5: Identify the following Ckts.

a.

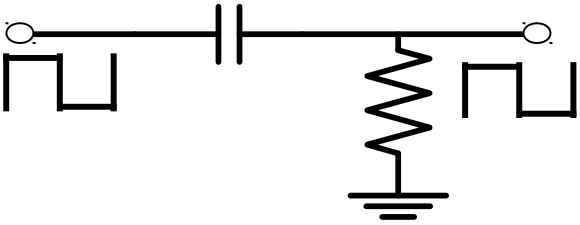


Integrator, Differentiator, Coupler ?

Identify: _____

---

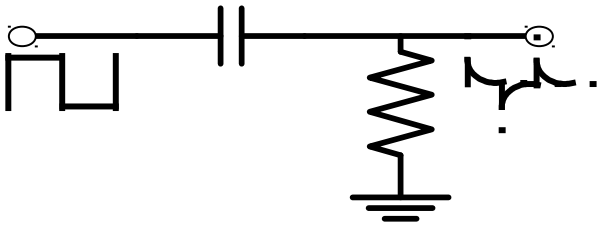
b.



Identify: _____

---

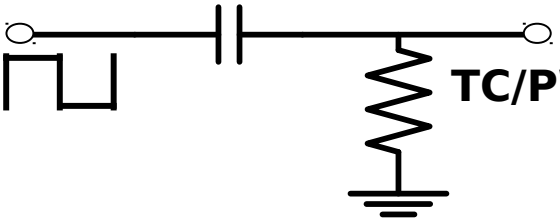
c.



Identify: _____

---

d.

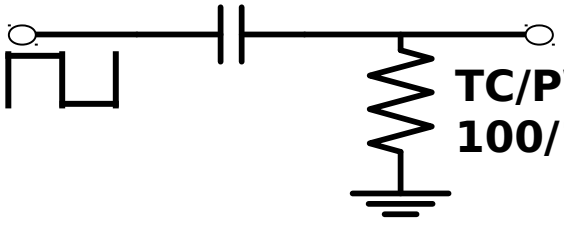


TC/PW = 1/10

Identify: _____

---

e.

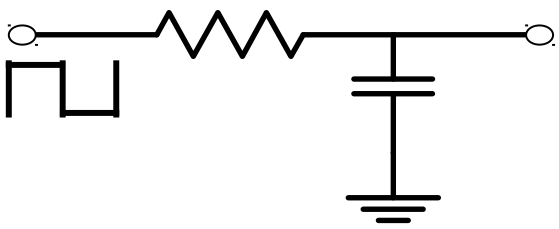


TC/PW = 100/1

Identify: _____

---

f.



Identify: _____

AC: Transients in RC Circuits.

Review; Reference White Gov Tng Aid.

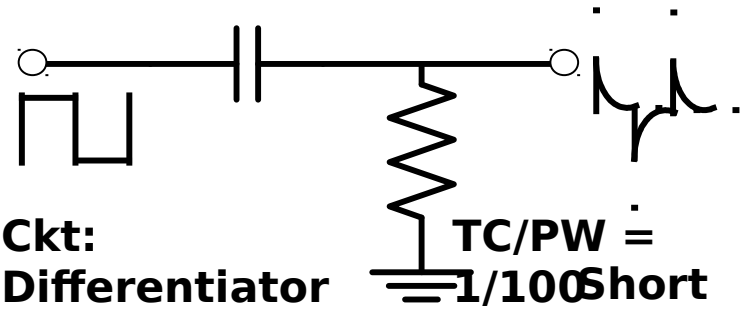
TC = R X C

PW= 1 / 2 X Freq

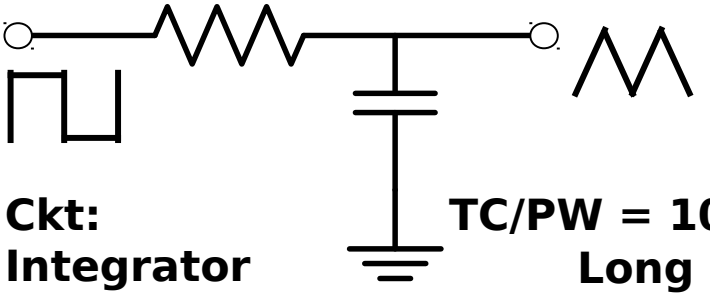
TC/PW Ratio, reduce fraction.

TC = Time Needed

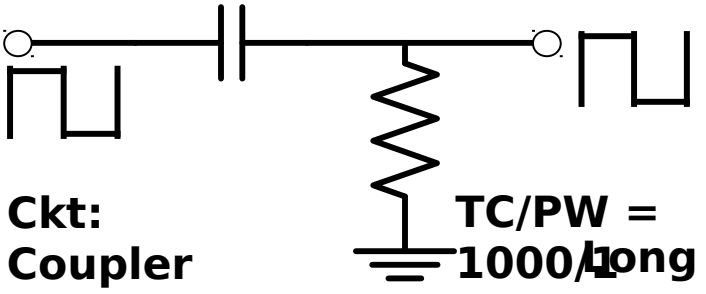
PW = Time Have



Ckt: Differentiator **TC/PW = 1/100** **Short**



Ckt: Integrator **TC/PW = 10/1** **Long**

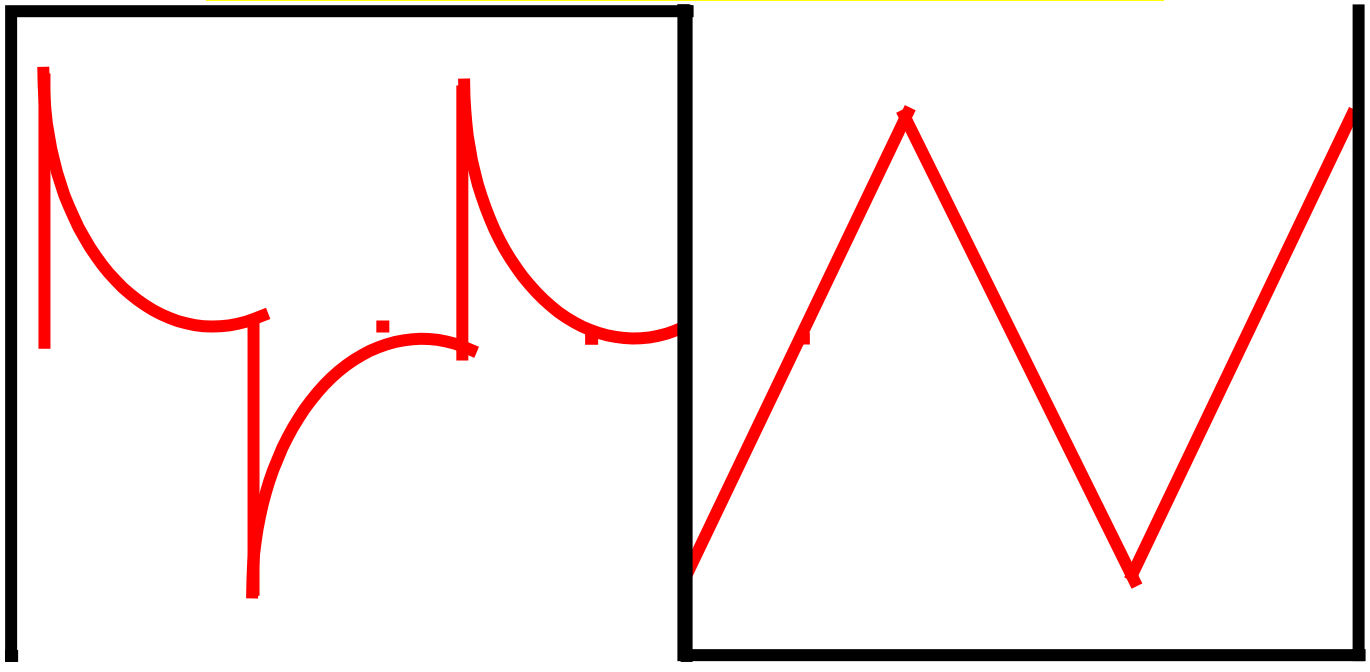


Ckt: Coupler **TC/PW = 1000/1** **Long**

Transients in LR Circuits

UNCLASSIFIED:

Safety & Environmental Impact; LOW



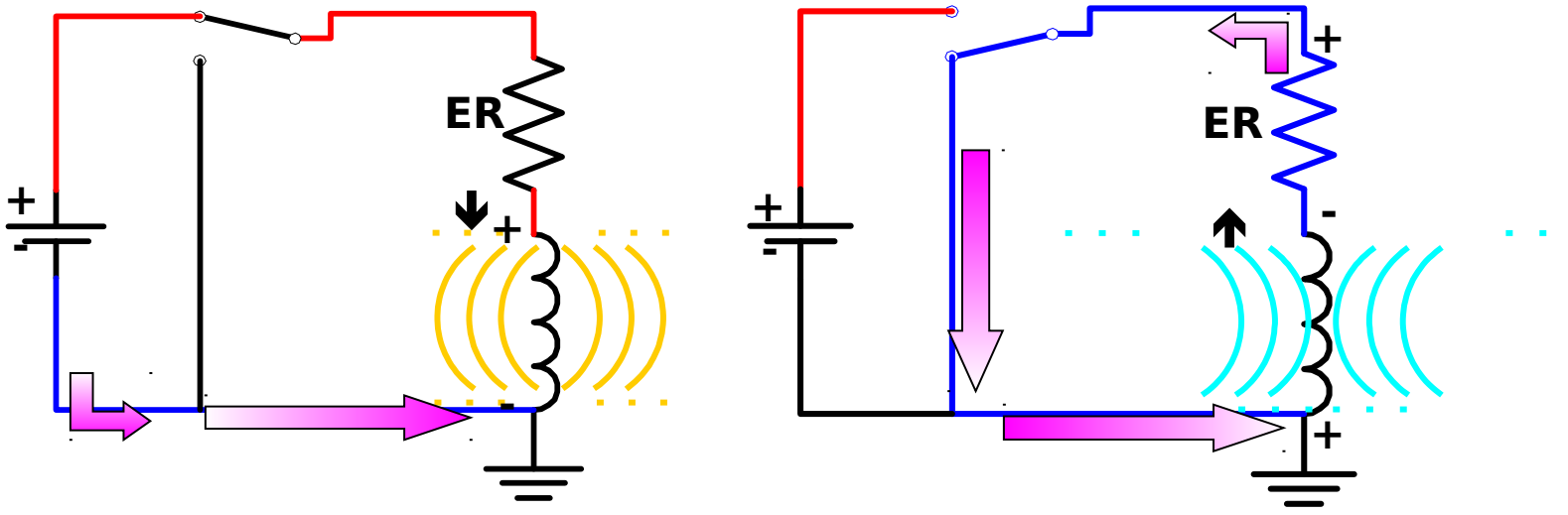
This lesson will enable you to determine what type of ckt is being used based upon the size of the Resistor & Inductor that will change the input waveform to a distinctly different waveform on the output.

These circuits are use extensively in private & defense electronics, for timing devices.

AC: Transients in LR Circuits, TC

LR Ckt;

A Ckt comprising of a Resistor & Inductor in series, where the rate [time] of Expansion & Contraction is dictated by the value [size] of the Resistor & Inductor.



TC;

TC = Time for current to reach approximately 63% of maximum expansion.

TC = L/R

L = 10 mh **R = 100 Ω**

In μSec only

10 EE $^{-3}$ ÷ 100 = .0001 Sec = 100 μS

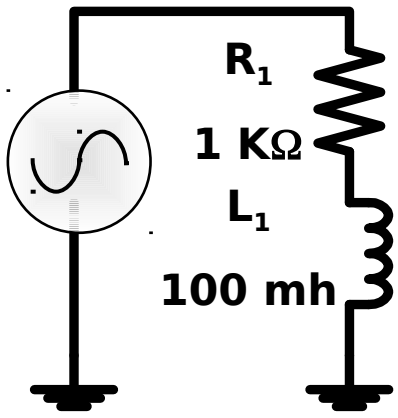
Move the decimal 6 places .000100.

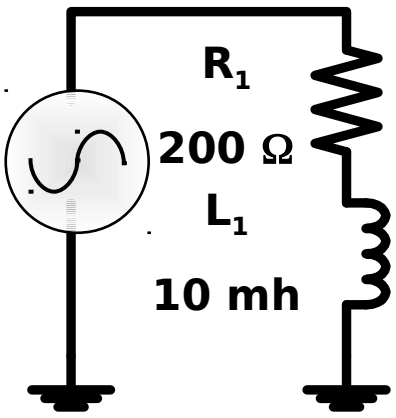
or On the calculator; 2nd Function 6 ⇒ 100^{-6}

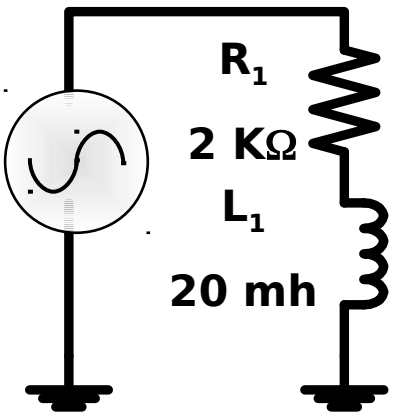
Reference White Gov Tng Aid.

AC: Transients in LR Circuits.

TC; Calculate the TC for the following Ckts.







TC =_____ **TC =_____** **TC =_____**

Pulse Width;

PW In μ**Sec** only **= 2 X Freq 1/X**

$$PW = \frac{1}{2F} \qquad PW = \frac{1}{2 \times Freq}$$

On the Calculator; Frequency = 10 KHz

10 EE³ X 2 = 1/X ⇒ .00005 Sec

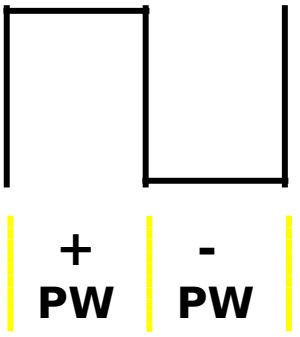
PW = .0000 50. μS

W/ 2nd Function Key; **PW = 50^{-6}**

PW Must be in **μS**

AC: Transients in LR Circuits.

Pulse Width; **Calculate PW = 2X Freq 1/X**



5 KHz PW = _____

1 KHz PW = _____

20 KHz PW = _____

TC to PW Ratio;

$$TC = \frac{\text{Time expand to}}{\text{Needed}}$$

$$PW = \frac{\text{Time to}}{\text{Have}}$$

The TC tells us how much time is NEEDED for the fields to 63% of maximum.

The PW tell us how much time we HAVE for the fields to expand 63% of maximum.

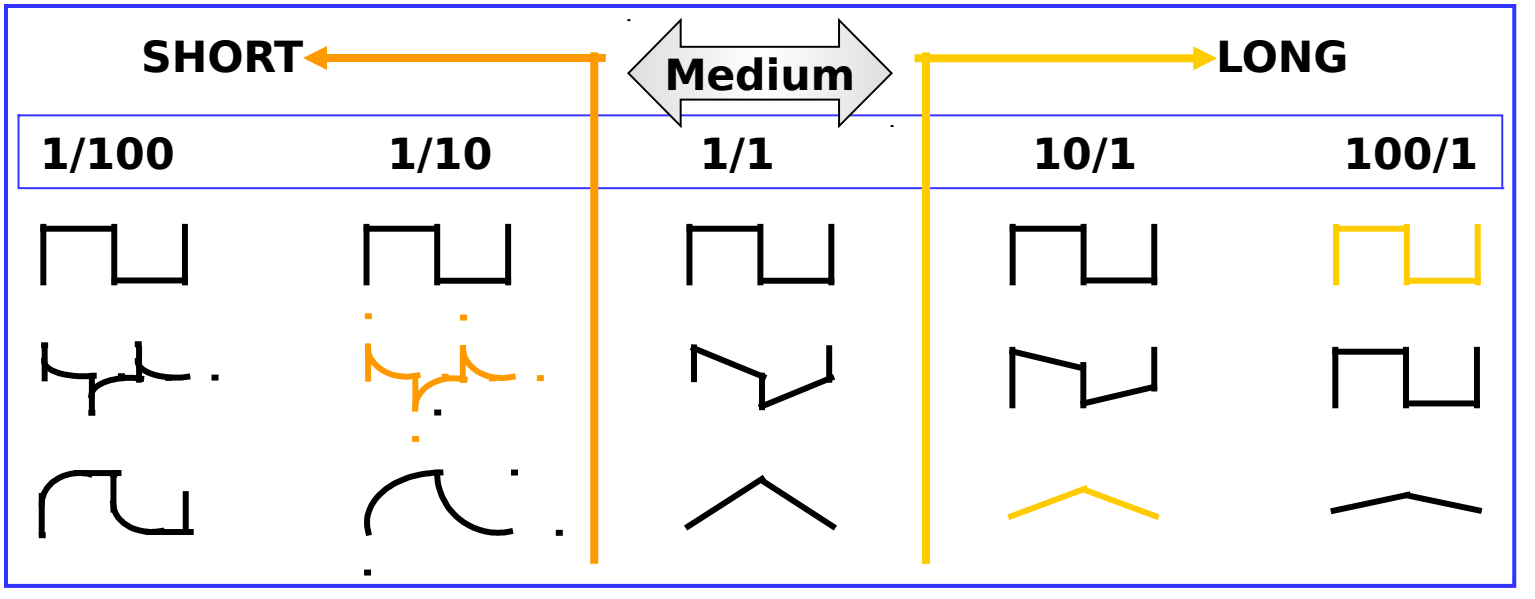
Reduce the Fraction;

$$TC = \frac{10\ \mu S}{PW = 100\ \mu S} \Rightarrow \frac{10}{100} \Rightarrow \frac{1}{10}$$

Strike out the common 0

Note; All fractions must be reduced to the lowest term of 1/# or #/1

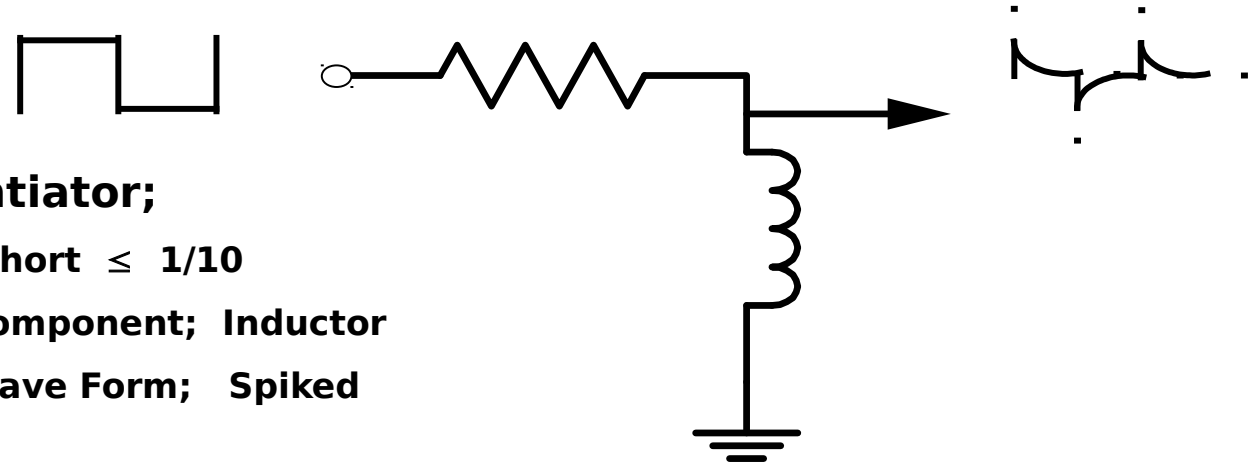
TC to PW Ratio; Chart



SLIDE; 9-10, 11, 12

AC: Transients in LR Circuits.

Ckt Types; Differentiator.



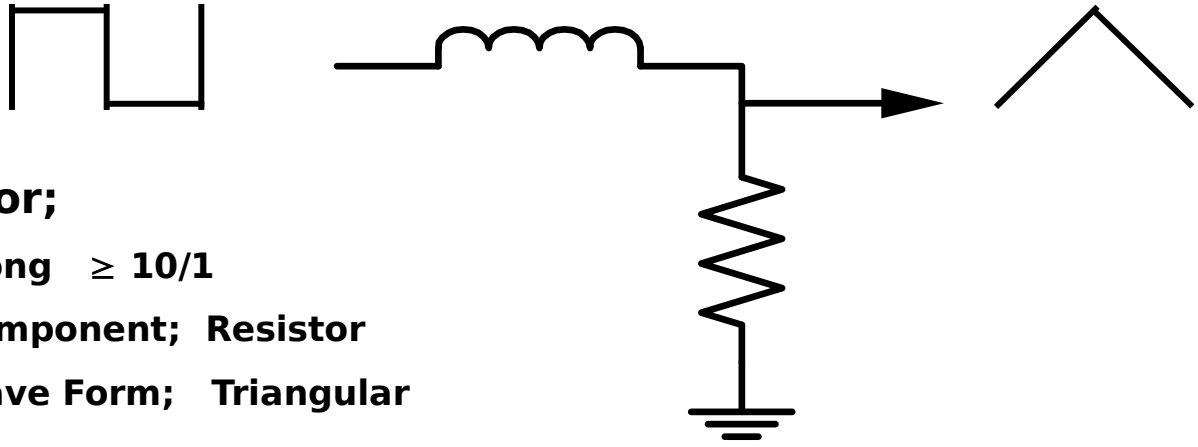
Differentiator;

TC/PW; Short ≤ 1/10

Output Component; Inductor

Output Wave Form; Spiked

Integrator.



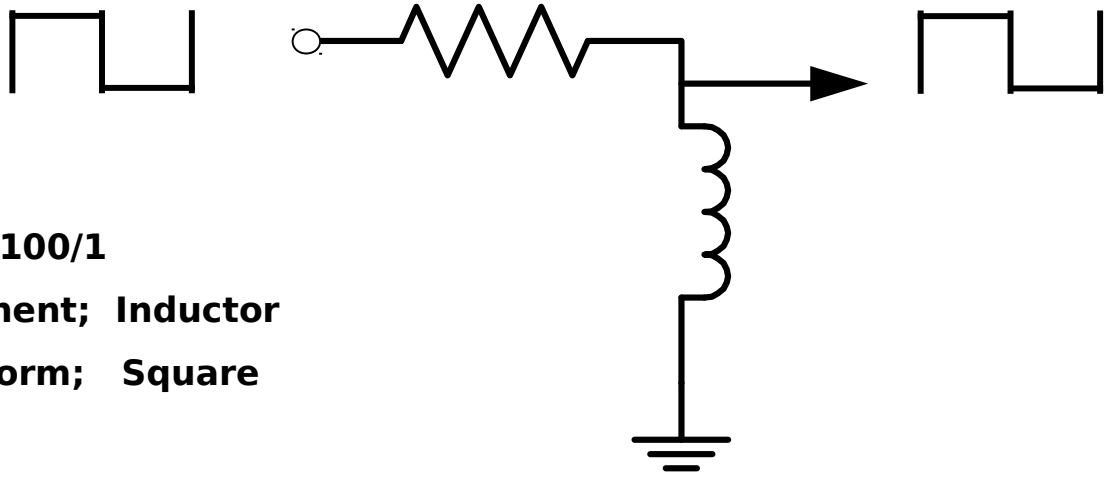
Integrator;

TC/PW; Long ≥ 10/1

Output Component; Resistor

Output Wave Form; Triangular

Coupler.



Coupler;

TC/PW; Long 100/1

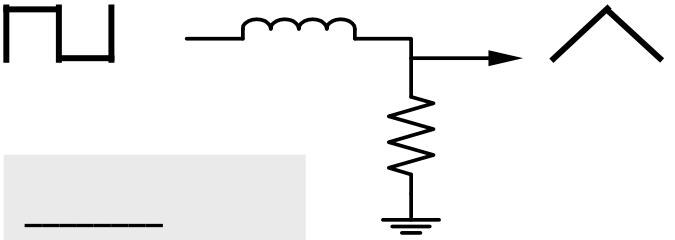
Output Component; Inductor

Output Wave Form; Square

AC: Transients in LR Circuits, Problem Sheets.

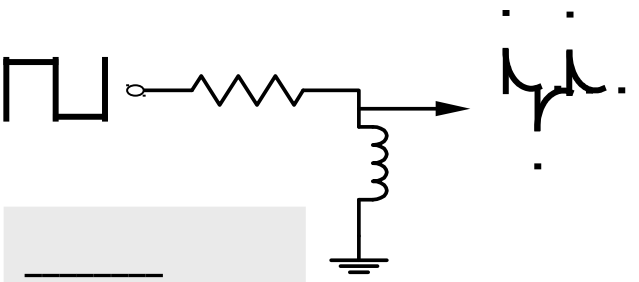
JOB 1; ID the Ckts as a Differentiator, Integrator, Coupler.

a.



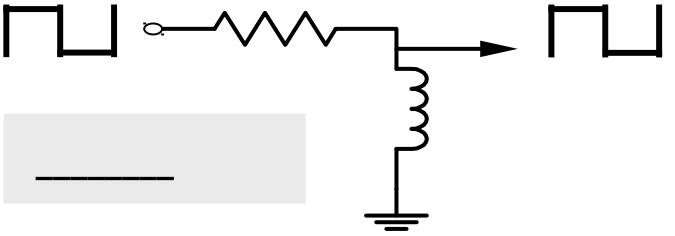
_____

b.



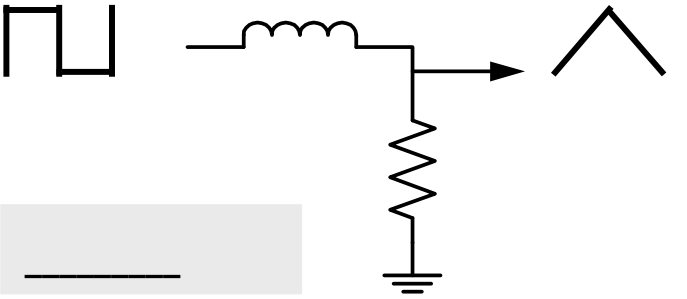
_____

c.



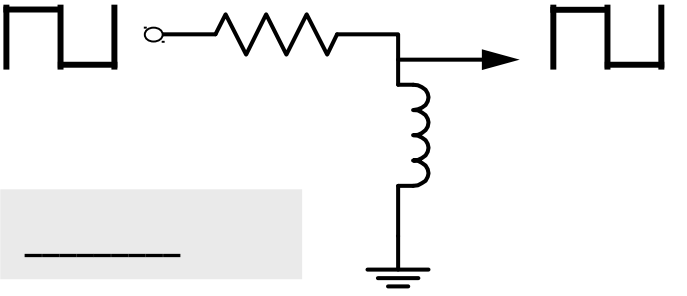
_____

d.



_____

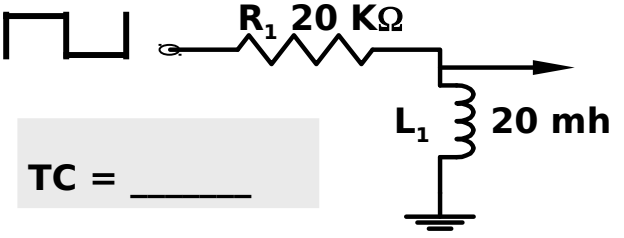
e.



_____

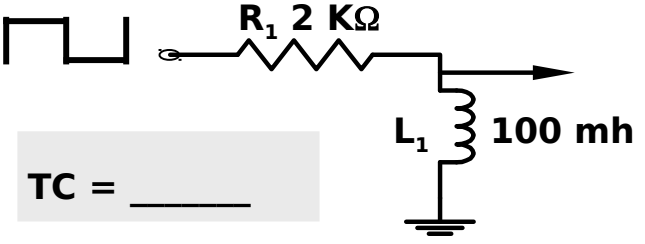
JOB 2; Calculate the TC of the following LR Ckts.

a.



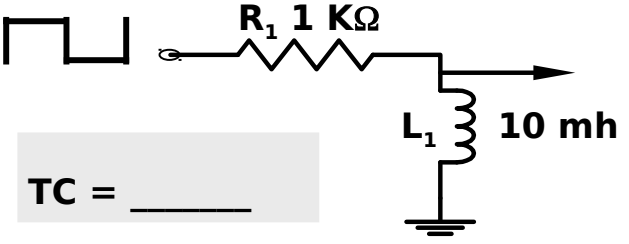
TC = _____

b.



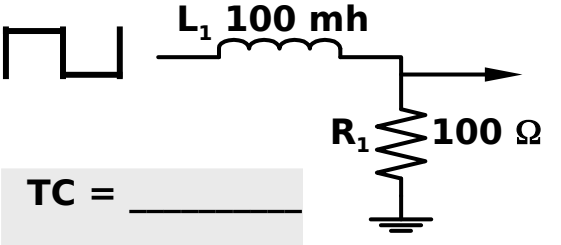
TC = _____

c.

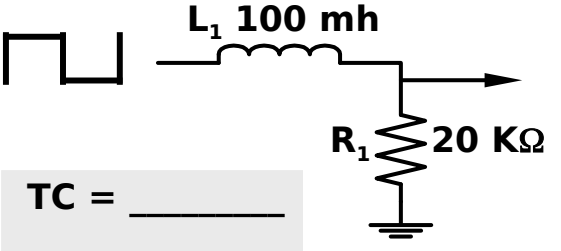


TC = _____

d.



TC = _____



TC = _____

AC: Transients in LR Circuits, Problem Sheets.

JOB 3; Calculate the PW of the following Frequencies.

a. Freq = 5 KHz PW = _____

b. Freq = 100 Hz PW = _____

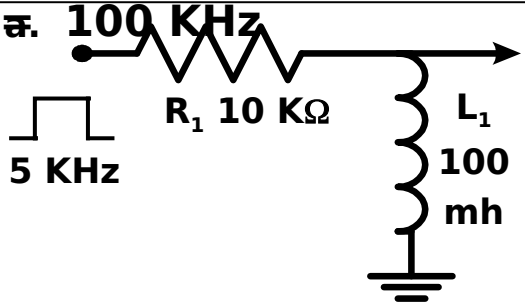
c. Freq = 15 KHz PW = _____

d. Freq = 25 KHz PW = _____

JOB 4; Calculate the TC /PW Ratio of the following LR Ckts.

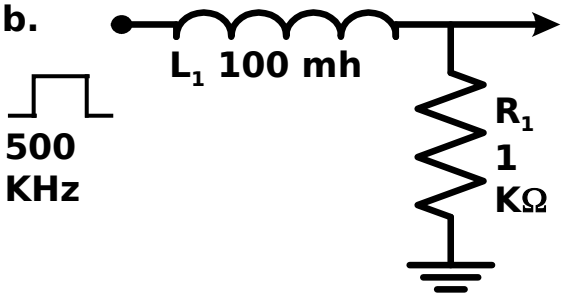
e. Freq = 100 KHz PW = _____

a.



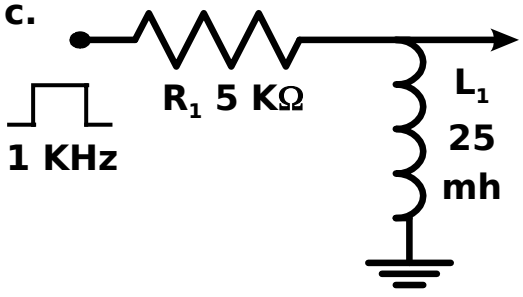
TC = _____
PW = _____
Ratio = _____
Name; _____
TC/PW = _____

b.



TC = _____
PW = _____
Ratio = _____
Name; _____
TC/PW = _____

c.

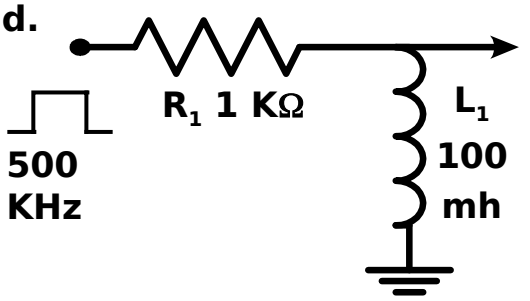


TC = _____
PW = _____
Ratio = _____
Name; _____
TC/PW = _____

AC: Transients in LR Circuits, Problem Sheets.

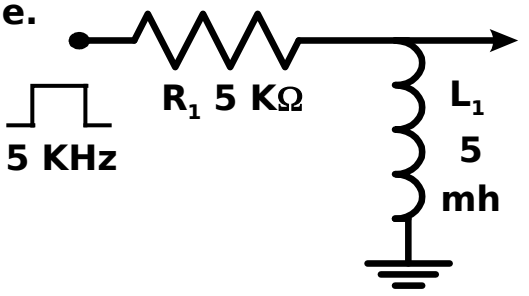
JOB 4; Calculate the TC /PW Ratio of the following LR Ckts.

d.



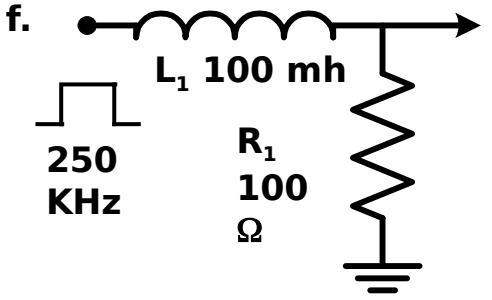
TC = _____
PW = _____
Ratio = _____
Name; _____
TC/PW = _____

e.



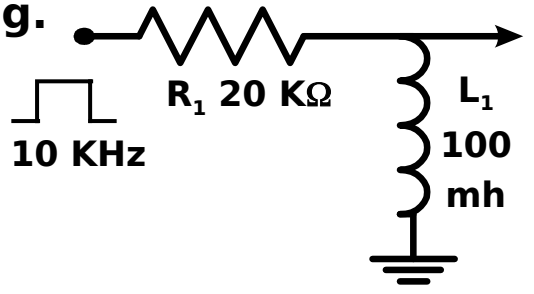
TC = _____
PW = _____
Ratio = _____
Name; _____
TC/PW = _____

f.



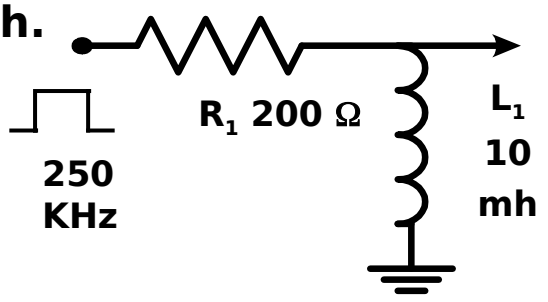
TC = _____
PW = _____
Ratio = _____
Name; _____
TC/PW = _____

g.



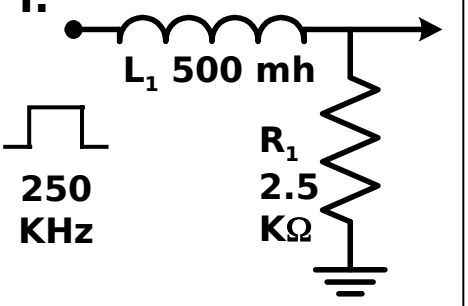
TC = _____
PW = _____
Ratio = _____
Name; _____
TC/PW = _____

h.



TC = _____
PW = _____
Ratio = _____
Name; _____
TC/PW = _____

i.

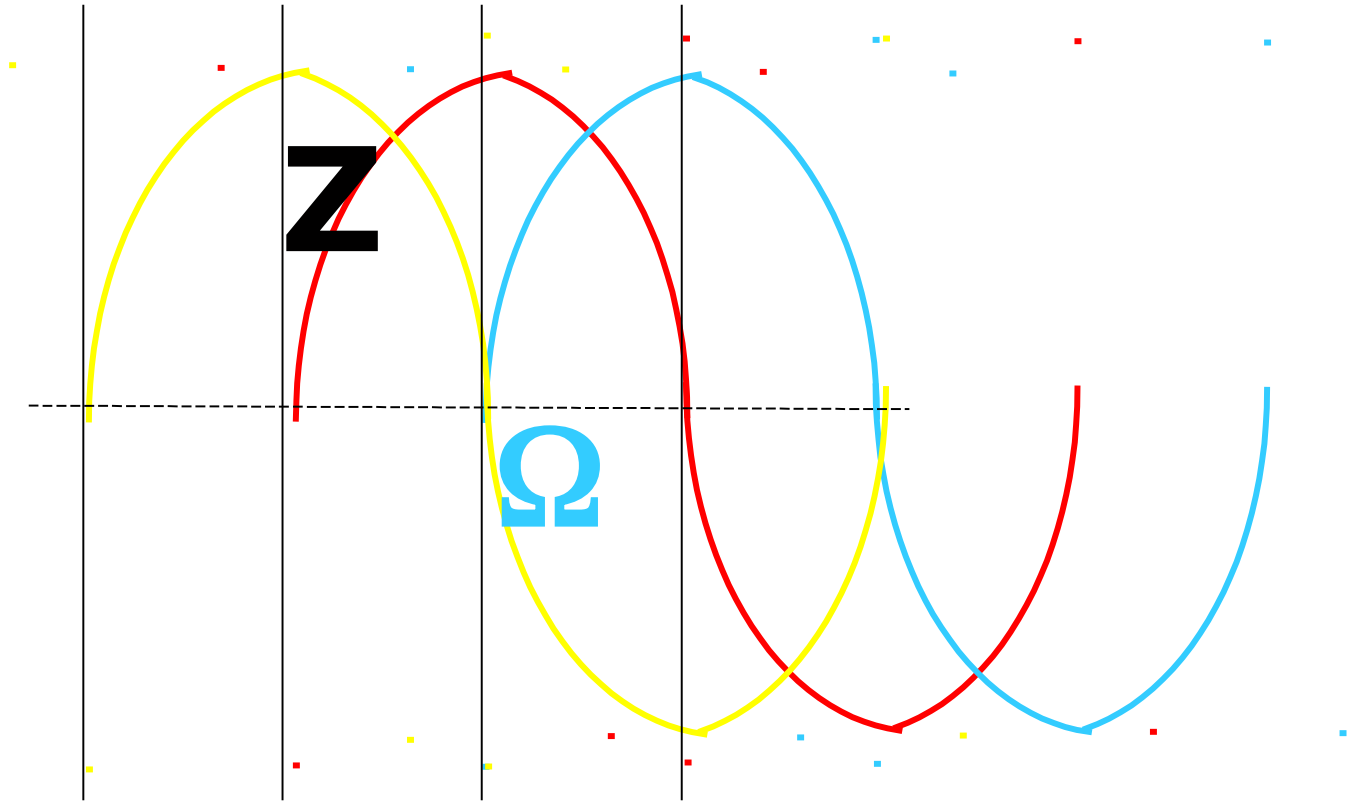


TC = _____
PW = --------
Ratio = _____
Name; _____
TC/PW = _____

LCR Circuits

UNCLASSIFIED:

Safety & Environmental Impact: LOW

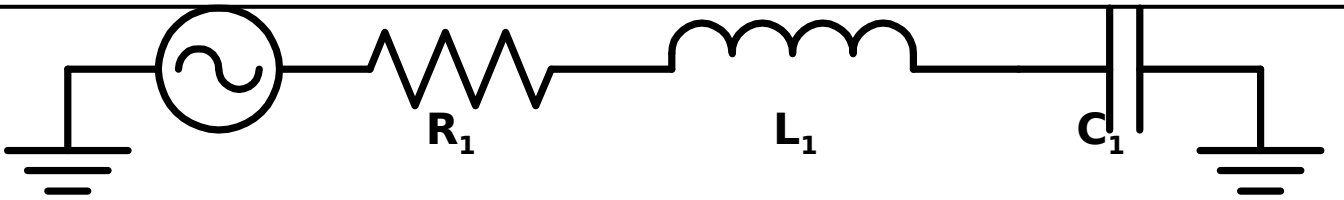


In previous lessons you learned of Inductive & Capacitive Ckts Concepts & how to calculate the operating parameters of each of them individually.

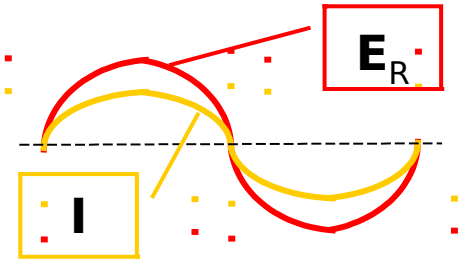
In this lesson we will combine all three devices in one Ckt & calculate its operating parameters & learn the Concepts of a Low & High Pass filters. These Ckts are used extensively in electronics equipment.

AC: LCR Circuits

LCR: A Ckt comprising of an Inductor, Capacitor & Resistor.

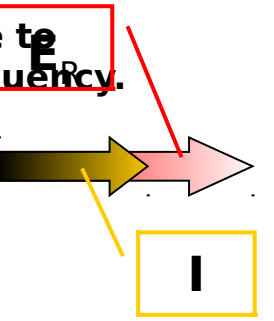


AC Resistor Concepts:

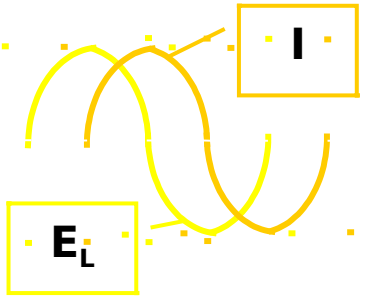


Resistors in an AC Ckt are <u>not</u> reactive to changes in Frequency.

Voltage & Current are in Phase.



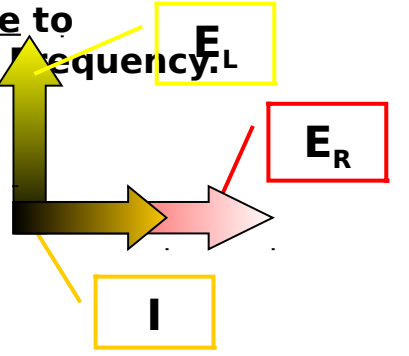
AC Inductor Concepts;



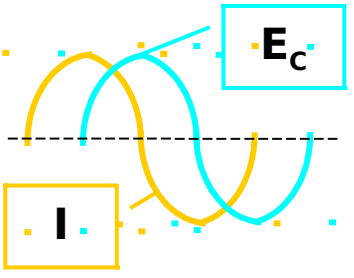
Inductors in an AC Ckt are <u>reactive</u> to changes in Frequency.

Voltage & Current are 90° Out of Phase.

Voltage leads Current by 90°.



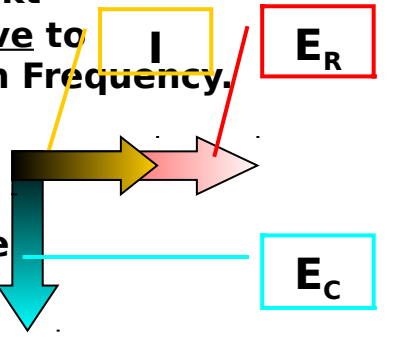
AC Capacitor Concepts;



Capacitors in an AC Ckt are <u>reactive</u> to changes in Frequency.

Current & Voltage are 90° Out of Phase.

Current leads Voltage by 90°.



AC: LCR Circuits

AC Inductor Concepts; **Because Inductors are frequency reactive devices their opposition changes w/ the change in Freq, the Inductive Reactance [opposition] must be calculated for.**

Ω

$$XL = 2\pi \times Freq \times Ind$$

Freq ⇧ XL ⇧ EL ⇧

Direct Relationship w/Freq

AC Capacitor Concepts; **Capacitors are frequency reactive devices their opposition changes w/ the change in Freq, the capacitive Reactance [opposition] must be calculated for.**

Ω

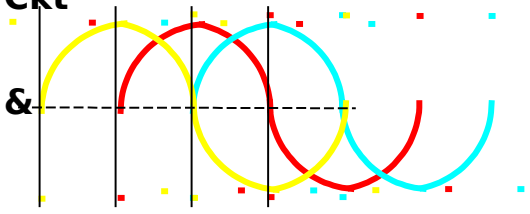
$$XC = \frac{1}{2\pi \times Freq \times Cap}$$

Freq ⇧ XC ⇩ EC ⇩

Indirect Relationship w/Freq

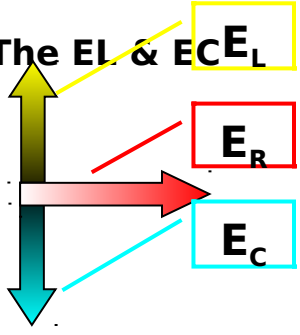
LCR Concepts;

Ckt



&

The EL & EC



When all three devices are in the same a 180° Out Phase relationship exists.

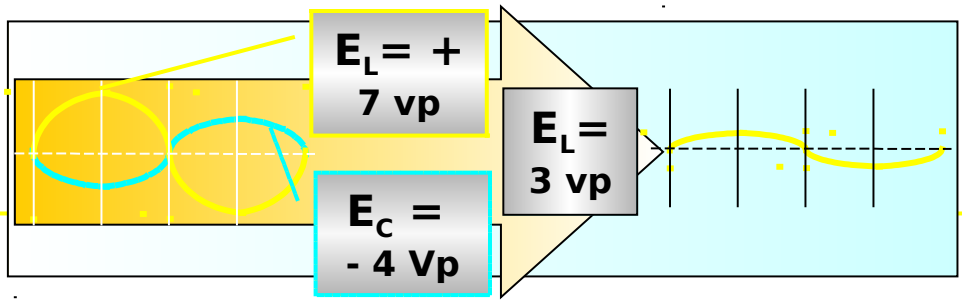
Because of this relationship, when the XL XC are Equal, they will cancel each other out.

Because of the Direct relationship of opposition & Voltage drops, will cancel each other out.

If one of the devices has more Opposition or Voltage Drop than the other it will cancel out the one w/the least, & the Greater will dominate the Ckt.

Freq ⇧ XL ⇧ EL ⇧

Freq ⇧ XC ⇩ EC ⇩



AC: LCR Circuits

Impedance; Is the total Opposition to AC, Unit Ω.

Because of the 180° Out Phase relationship of the XL & XC the difference must be calculated.

If they are Equal, they will cancel each other out, and only Resistance remains.

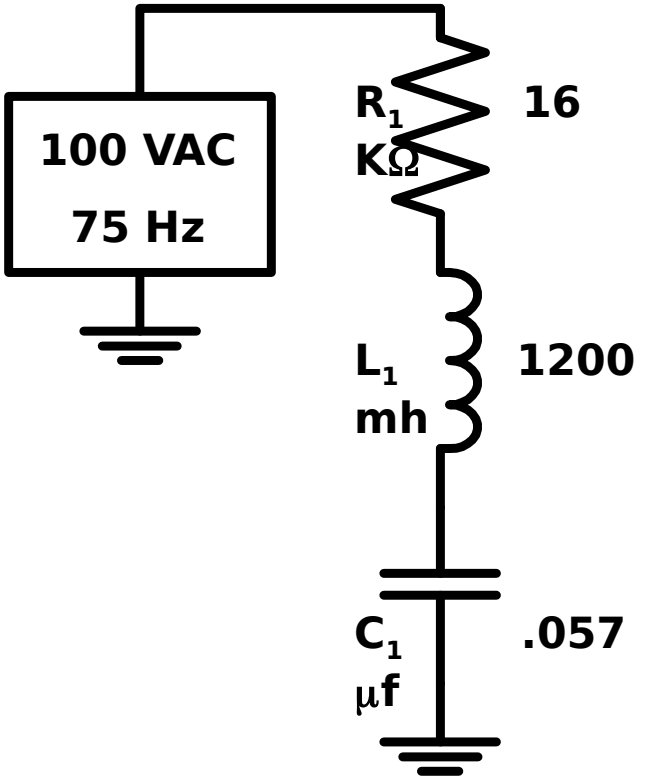
Formula;

$$Z = \sqrt{RT^2 + \{ XL - XC \}^2}$$

Mathematical Order of Precedence, Memory Aid;

Please Sally	Excuse	My	Dear	Aunt
{ } -	X^2	X	÷	+
1. Parentheses	2. Exponent	3. Multiply	4. Divide	5. Add
6. Subtract				

Impedance; Calculate the Opposition parameters;



R_T = _____

XL_T = _____

XC_T = _____

Z = _____

IT = _____

ER1 = _____

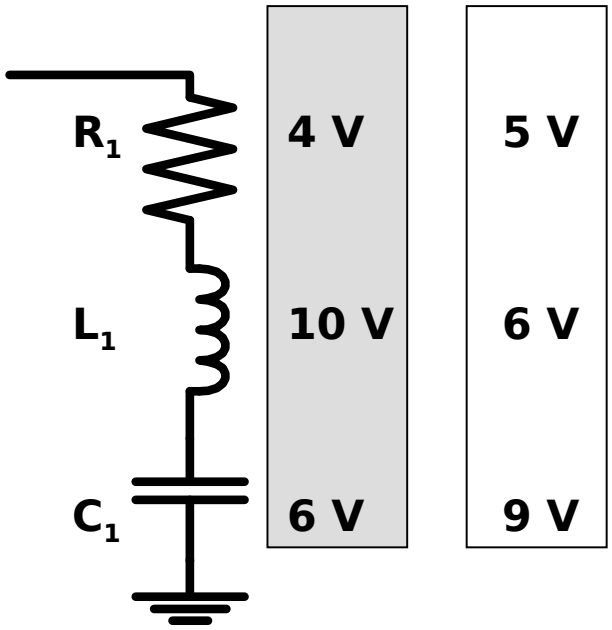
EL1 = _____

EC1 = _____

EA = _____

AC: LCR Circuits

Calculate; The Applied Voltage, EA & EA.



EA = _____

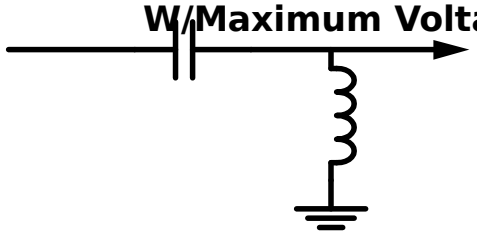
EA = _____

$$EA = \sqrt{ER^2 + \{EC - EL\}^2}$$

$$EC - EL = X \quad X = \sqrt{X^2 + ER^2}$$

FILTERS; 2 types, High Pass & Low Pass.

High Pass Filter;
W/Maximum Voltage.

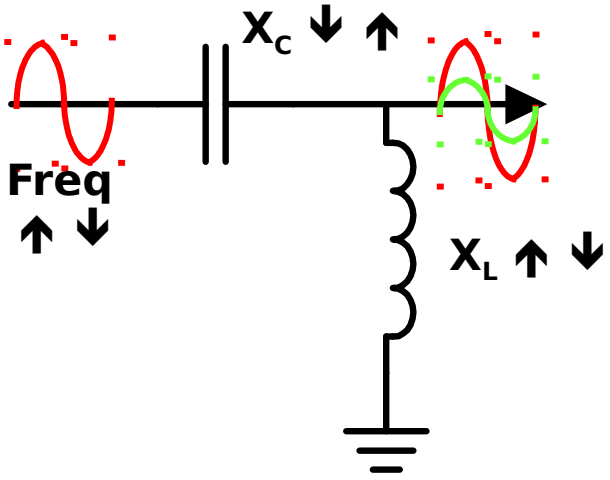


Passes high frequency

Attenuates the low Freq.

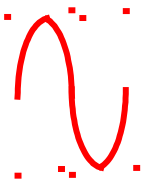
Attenuation is the Reduction in magnitude of any electrical parameter of a signal.

The Output is taken across the Inductor.



Passing the High;

1. X_C ↓ acts like a Short.
2. X_L ↑ Acts like an Open



Attenuates the Low;

1. X_C ↑ acts like a Open.
2. X_L ↓ Acts like an Short

Reference: White Gov Tng Aid, panel C.

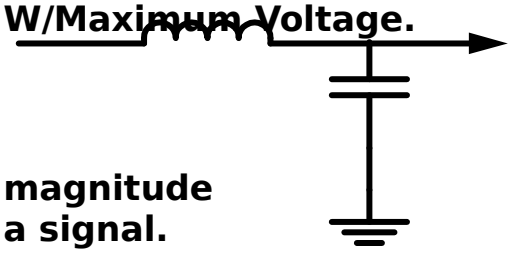
SLIDE; 14-15, 16

AC: LCR Circuits

FILTERS;

Low Pass Filter;

W/Maximum Voltage.



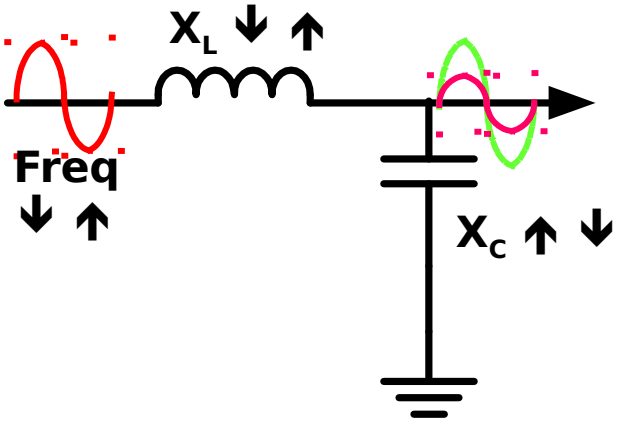
magnitude a signal.

<u>Passes Low frequency</u>

<u>Attenuates the High</u> Freq.

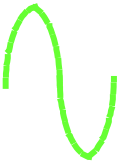
Attenuation is the Reduction in of any electrical parameter of

The Output is taken across the Capacitor.



Passing the Low;

1. **X_C ↑ acts like a Open.**
2. **X_L ↓ Acts like an Short.**



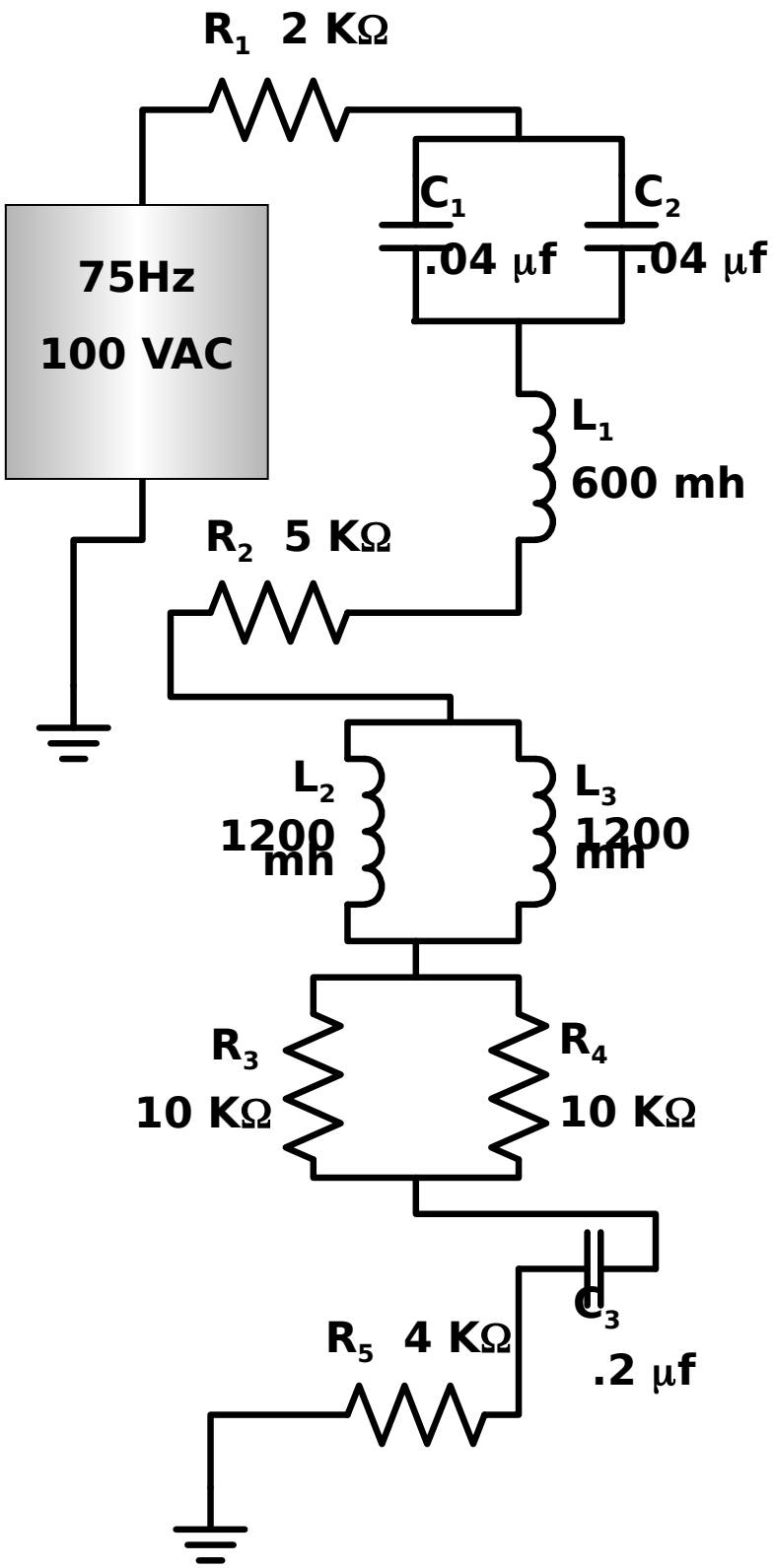
Attenuates the High;

1. **X_C ↓ acts like a Short.**
2. **X_L ↑ Acts like an Open.**

Reference: White Gov Tng Aid, panel C.

AC: LCR Circuits

Master Challenge; **Calculate the operating parameters.**



X_{LT} = _____

X_{CT} = _____

R_T = _____

Z = _____

I_T = _____ 3 Decimal places

E_{R1} = _____

E_{R2} = _____

E_{REQ} = _____

E_{RT} = _____

E_{R5} = _____

E_{CEQ} = _____

E_{CT} = _____

E_{C3} = _____

E_{L1} = _____

E_{LT} = _____

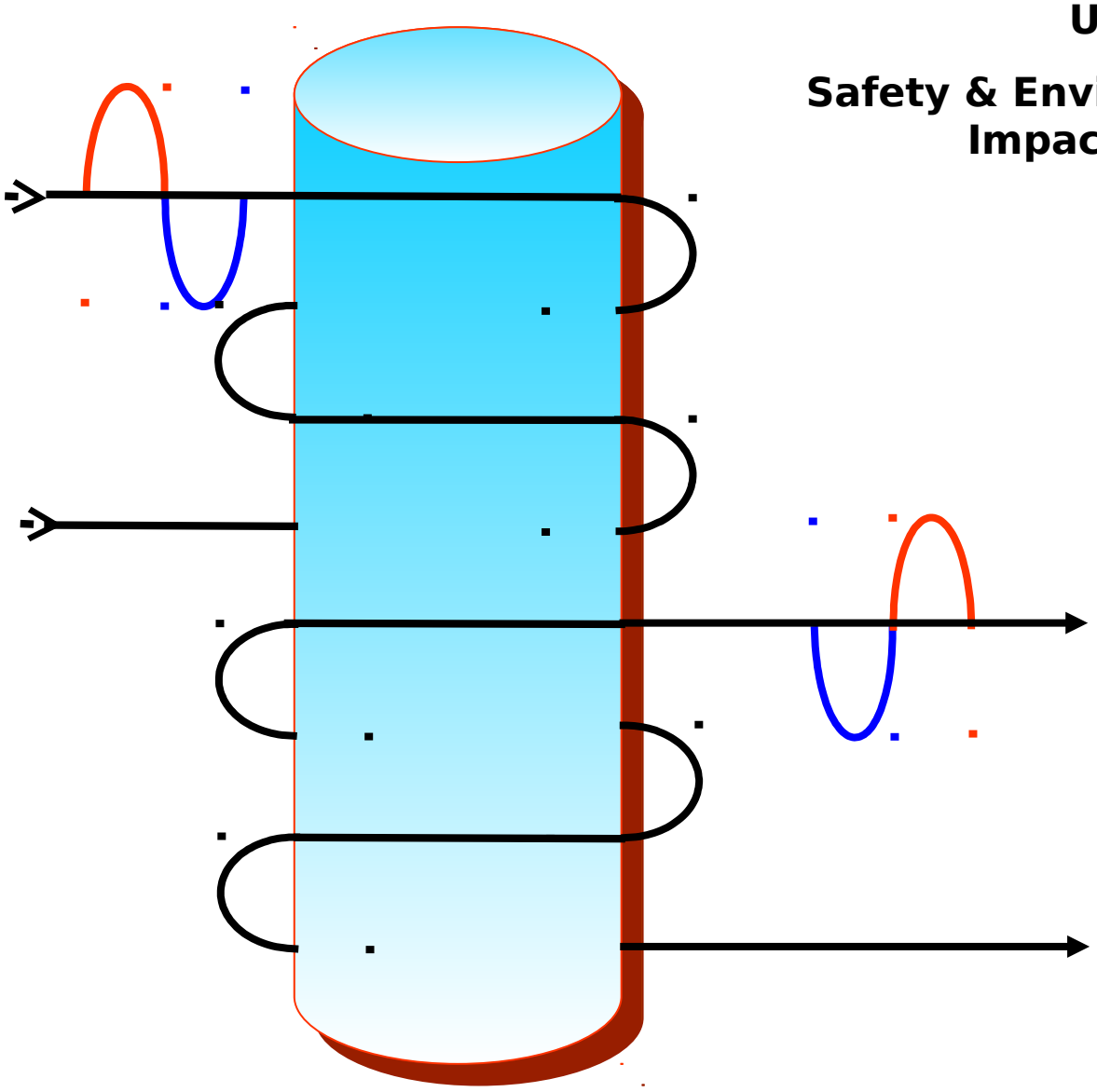
$EA = E_{LEQ}$ _____

AC:

TRANSFORMERS

Unclassified

Safety & Environmental Impact is “LOW”



AC would have never reached its high level of use if it were not for the transformer.

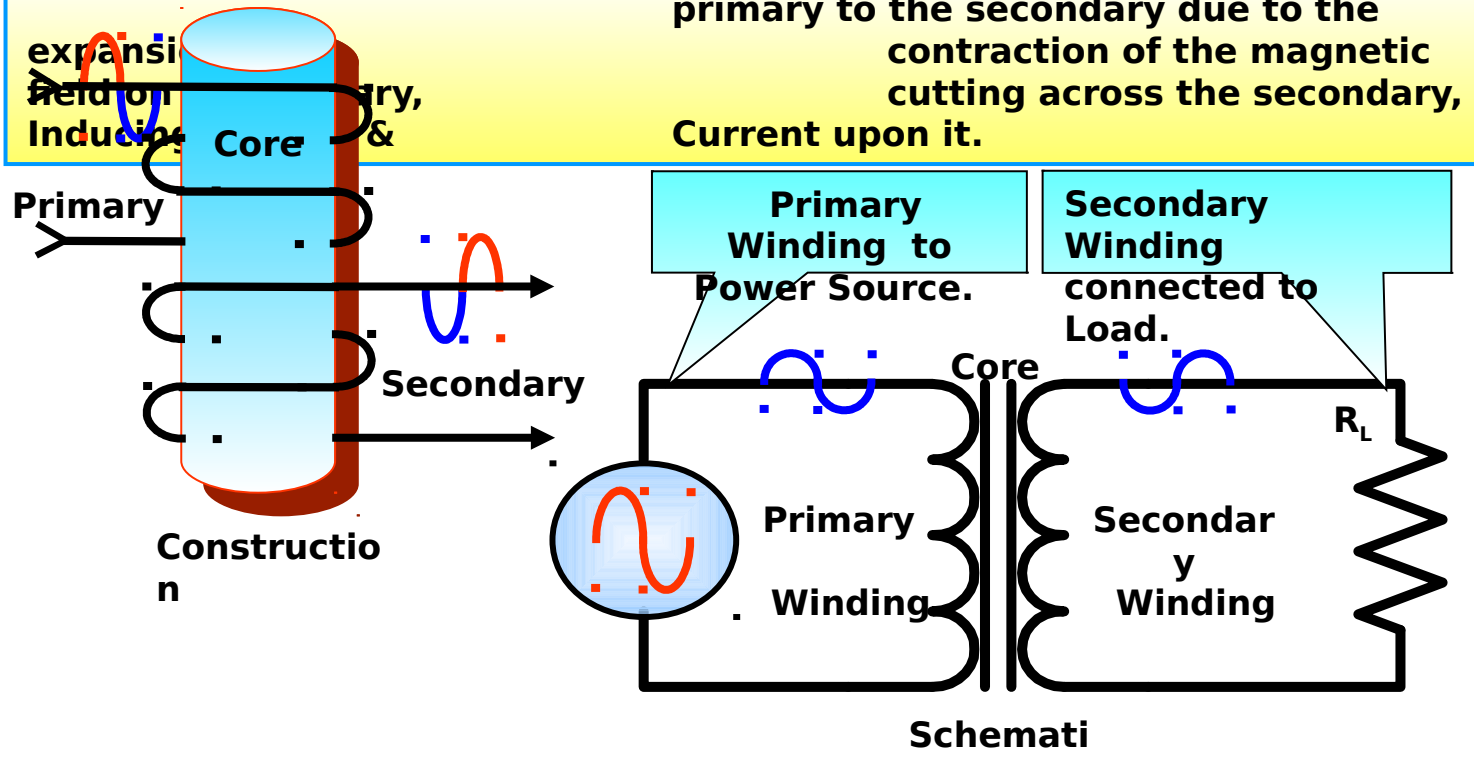
Transformers make it possible to change AC voltage and current values. They provide a way for efficiently transferring electric current long distances.

During this lesson you are going to study the transformer in detail.

AC: Transformers

Concept; A transformer changes the AC input Voltage and Current from one value on the input to a different value on the output.

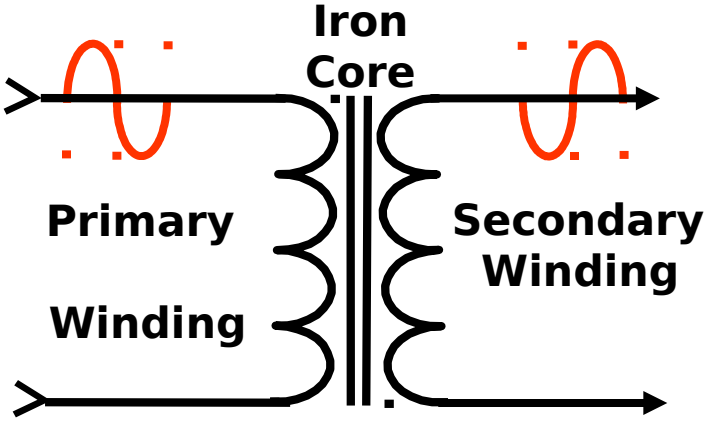
Mutual Inductance; The process of transferring the energy from the primary to the secondary due to the expansion & contraction of the magnetic field of the primary, Inducing cutting across the secondary, & Current upon it.



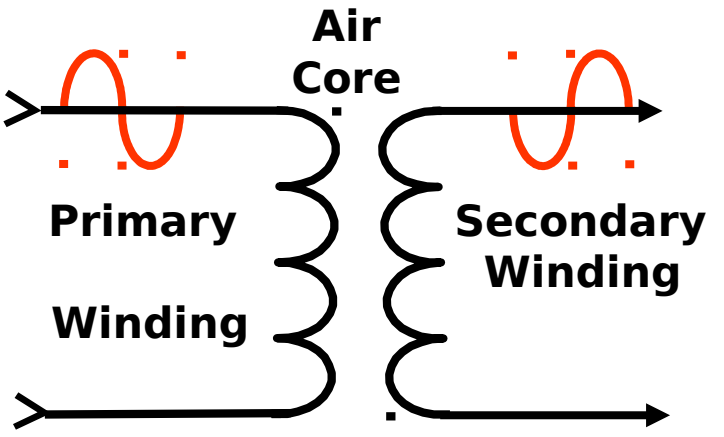
Core Types; Transformers will have either an Air Core or an Iron Core, dependent upon the application.

Iron core: Used with audio frequencies [AF] between 20 Hz & 20 KHz.

Air core: Used with radio frequencies [RF] 20 KHz and above.



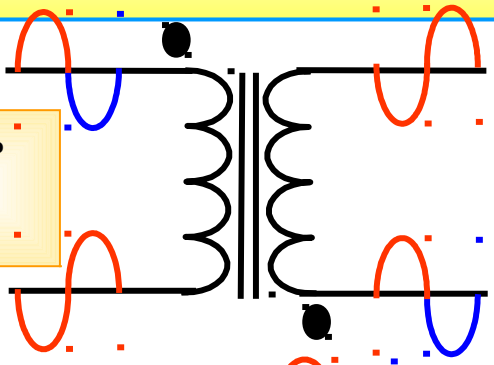
Schematic; Low Freq



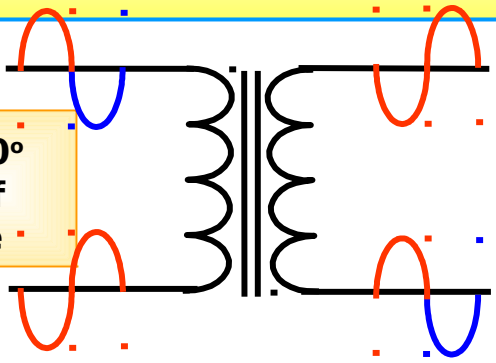
Schematic; High Freq

Phase Shift; The expansion & contraction of the magnetic fields around the primary onto the secondary coil is such that current is induced in the secondary coil. Current flows in the opposite direction than the primary, A 180° phase shift is the evident result.

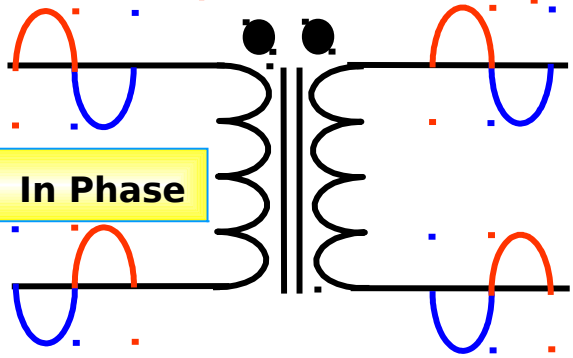
A. 180° Out of Phase



B. 180° Out of Phase



C. In Phase



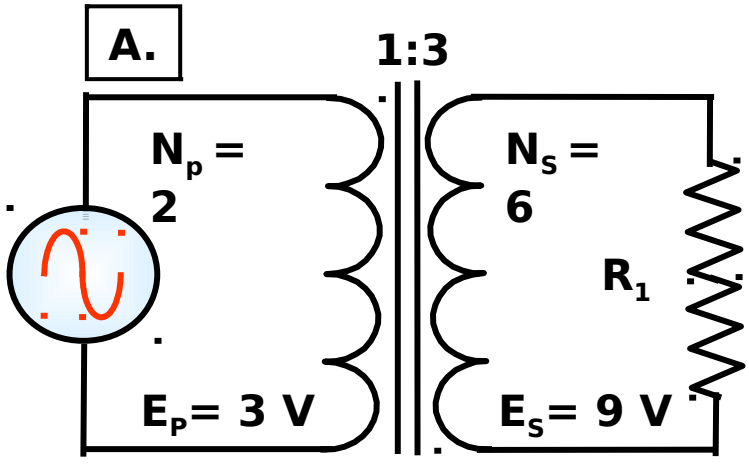
In Phase;

A core can also be wound so that the Primary & Secondary are in Phase, these are less common & incur additional expense.

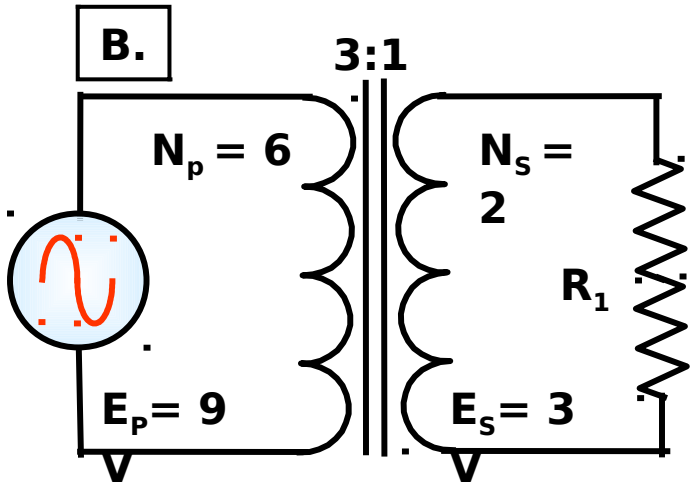
Turns Ratio; N_p = # of turns in primary. E_P = Voltage on Primary

N_S = # of turns in Secondary. E_S = Voltage on Secondary

A.



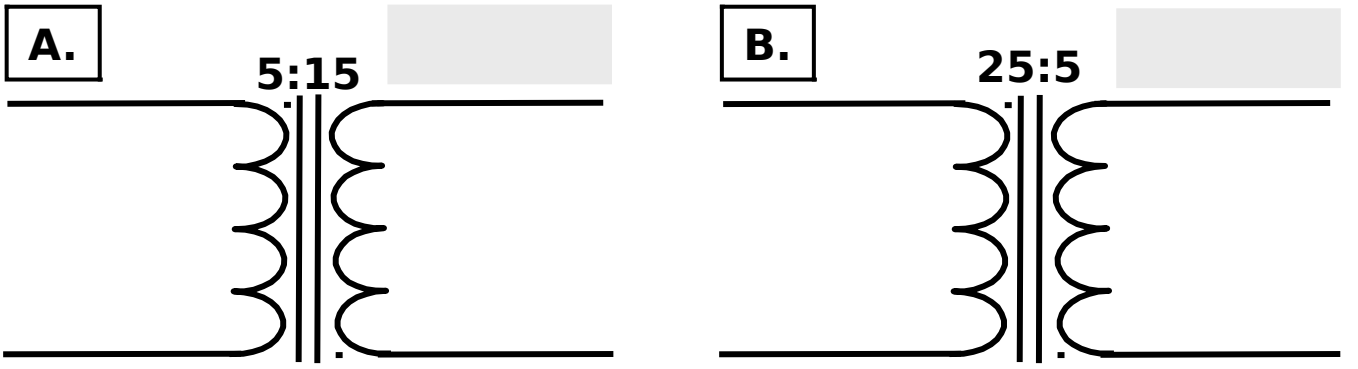
B.



AC: Transformers

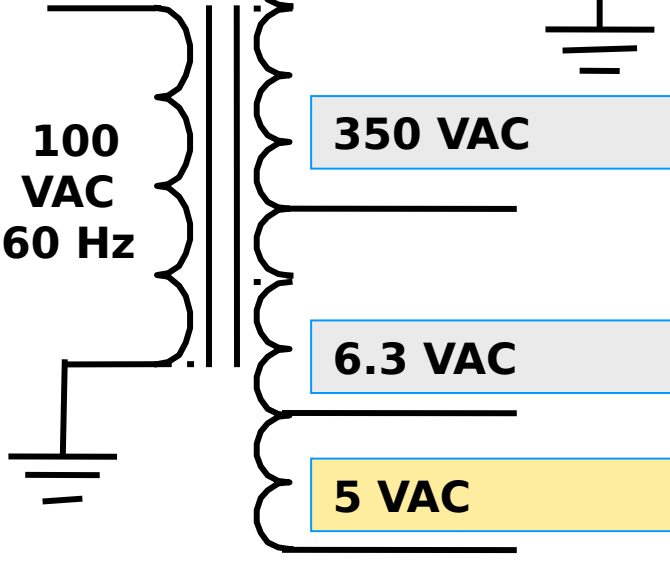
Turns Ratio; Is always reduced & expressed in the lowest terms with one of the numbers being "1".
The Largest number represents how many times greater the Voltage is than the smaller Number.

What is the turns ratio?



Multiple Transformer windings; Provides several different output voltages on the Secondary. Reducing the voltages determine the Ratio, from Primary to Secondary.

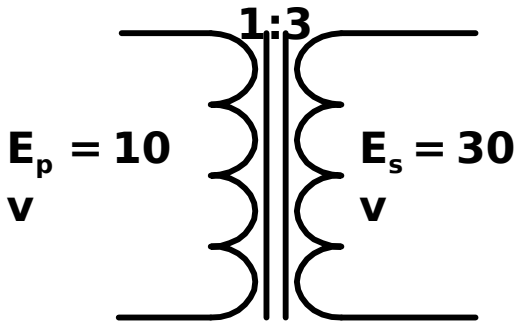
Multiple Secondary. Power Transformer



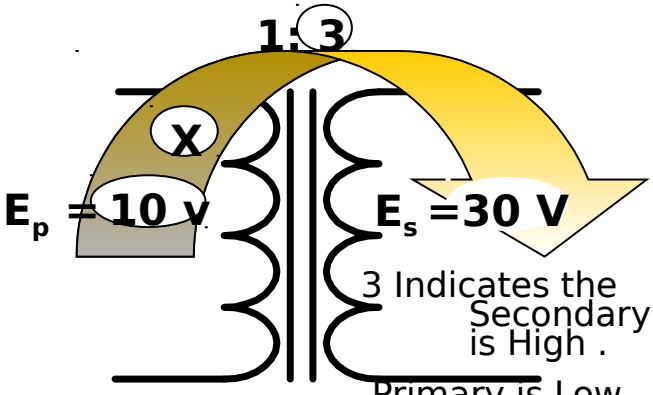
E_P / E_S = Ratio

350 VAC	100 / 350 = 1 : 3.5
350 VAC	___ / ___ = __ : __
6.3 VAC	___ / ___ = __ : __
5 VAC	100 / 5 = 20 : 1

Step Up Voltage, Step Down Current.



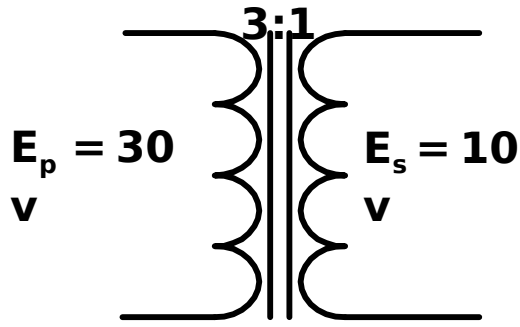
Step-Up Transformer



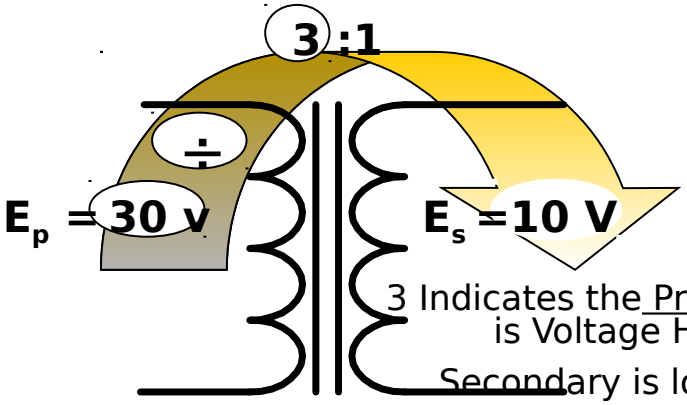
3 Indicates the Secondary Voltage is High .

Primary is Low.

Step-Up Transformer



Step-Down Transformer



3 Indicates the Primary is Voltage High .

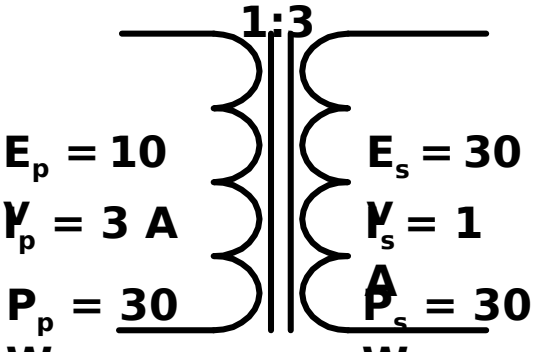
Secondary is low .

Step-Down Transformer

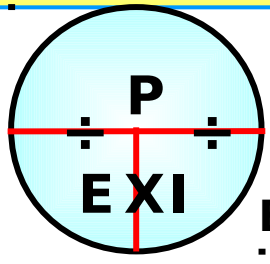
Power; Power in, is equal to, Power out. Transformers will be considered 100% efficient. $E_P \times I_P = E_S \times I_S$

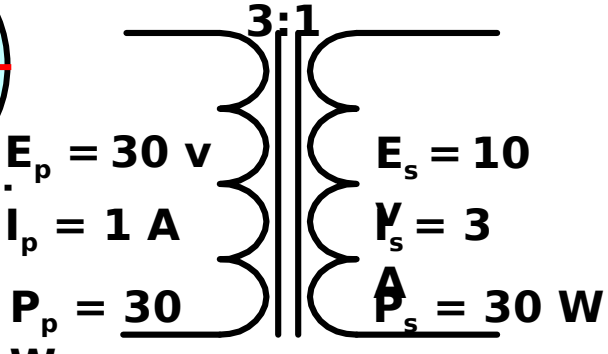
Voltage (E) is stepped up, Current (I) is stepped down.

Power is a product of Voltage & Current, E X I = P



Step-Up Transformer





Step-Down Transformer

AC: Transformers

Calculate; For the unknown, Voltage, Current & power.

T 1 1:2

E_P = 5 V E_S = ___V

I_P = 2 A I_S = ___ A

P_P = ___W P_S = ___W

T 2 5:1

E_P = ___V E_S = 3 V

I_P = ___A I_S = 10 A

P_P = ___W P_S = ___W

T 3 1:4

E_P = 2 V E_S = ____V

I_P = 6 A I_S = ____ A

P_P = ___W P_S = ___W

T 4 1:3

E_P = ___ V E_S = ___V

I_P = ____A I_S = ___ A

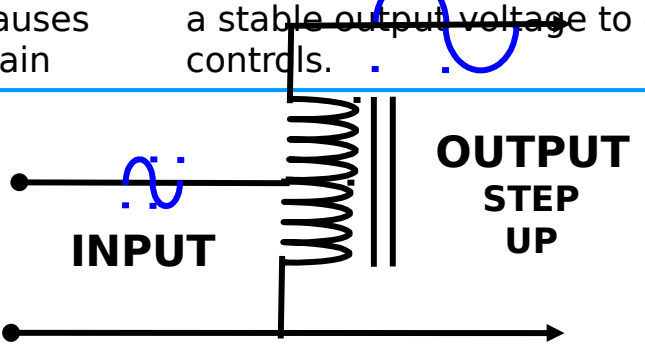
P_P = ___W P_S = ___W

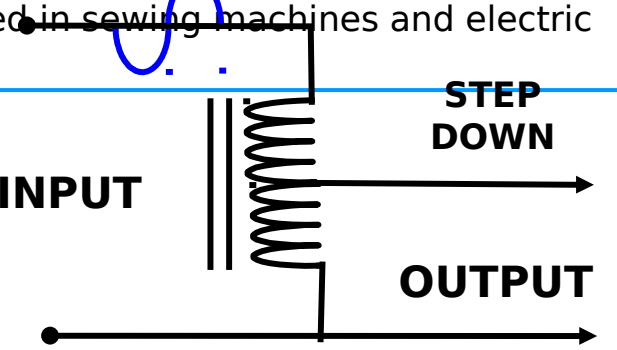
Autotransformers; **Have only one winding & a common wires for the primary and secondary. Both the primary and secondary currents flow through the same wire.**

Cheaper, because of the one winding and smaller core.

Disadvantage; No isolation between the circuit and the line. A shock hazard

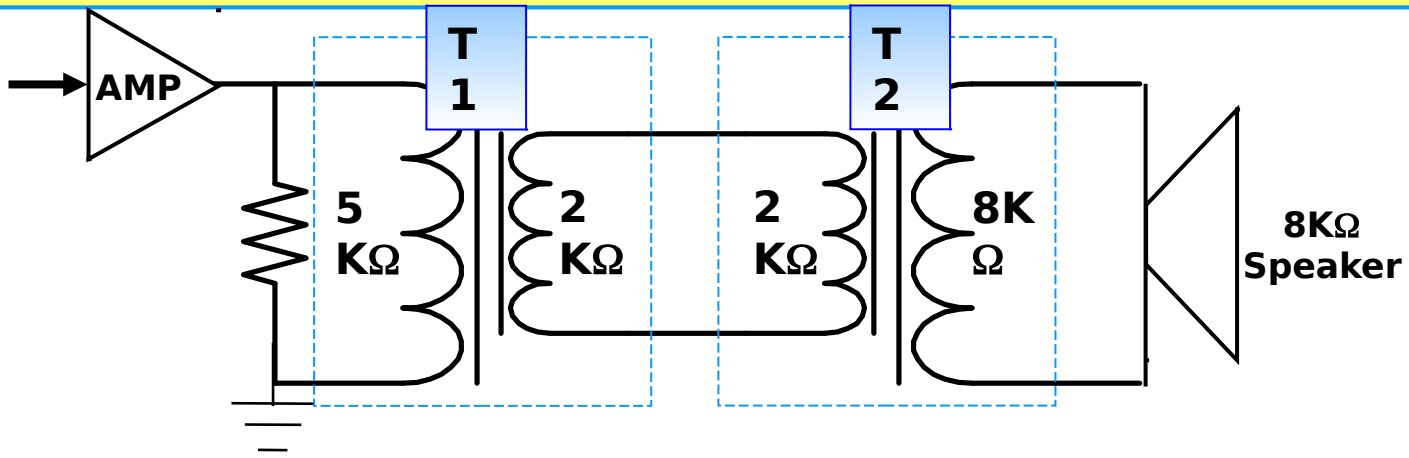
"Autotransformer" comes from the automatic voltage regulation they provide. Despite changes in load current, the opposing currents strike a balance which causes a stable output voltage to exist. Used in sewing machines and electric train controls.





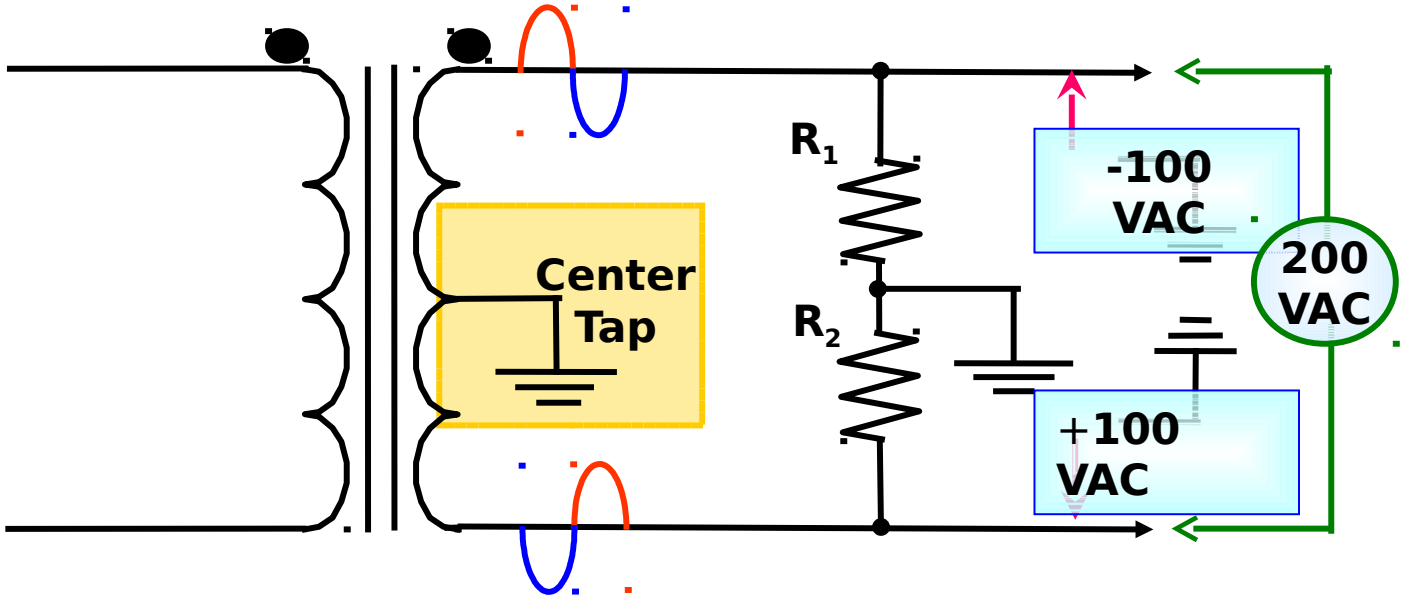
Impedance matching; **For maximum power output.**

Transformers are often used to match impedance between two circuits because the number of turns on the primary and secondary windings can be controlled in manufacturing.



Impedance Matching

Center Tap; **Placing a ground on the secondary winding, creates two Voltages the same but opposite in polarity. This ground is referred to as a "Center – Tap".**



AC: Transformers

JOB: 1 Transformer Operating Principles.

a. What is the definition of a transformer: _____

b. Name the winding which has power applied to it: _____

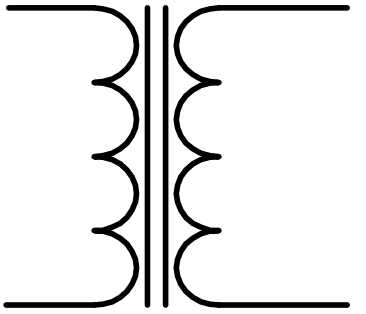
c. Name the winding which has the load connected to it: _____

d. What are the three major parts of the transformer.

_____

_____

_____



e. What type of core is used in increase transformer efficiency at low frequencies? _____

f. What is the principle of operation of a transformer?

_____

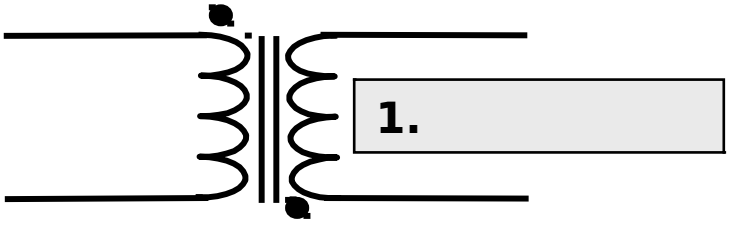
g. Will a transformer transfer AC power from the primary to the secondary?

_____

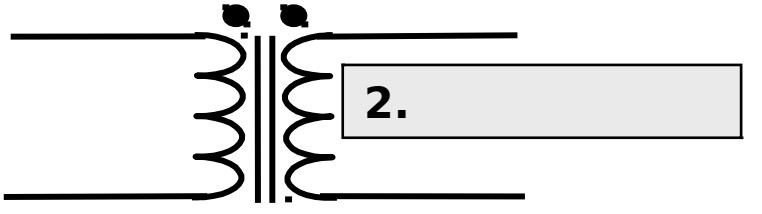
h. Will a transformer transfer DC power from the primary to the secondary?

Why?

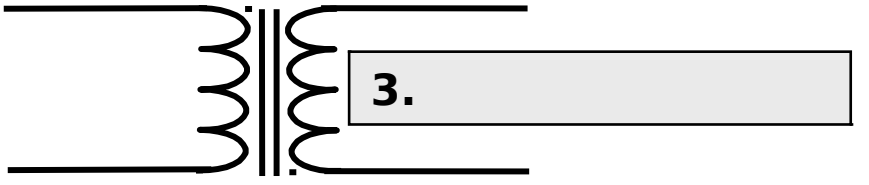
i. What is the phase relationship between primary and secondary voltages for the following transformers:



1.



2.



3.

JOB: 2 Solve for turns ratio, primary and secondary Voltages, Current & Power.

a.

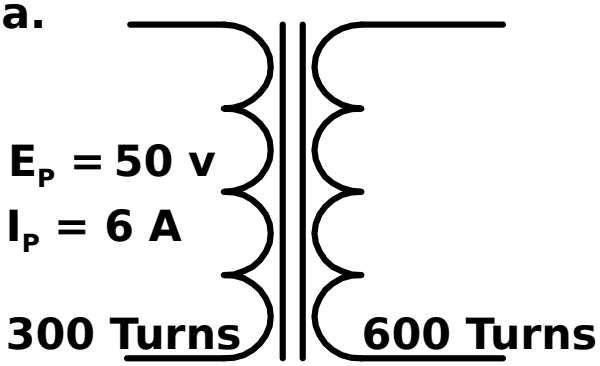


Figure 1

1. Phase relationship = _____
2. Type of Core = _____
3. Turns Ratio = _____
4. Step Up/Down = _____
5. Secondary Voltage = _____
6. Secondary Current = _____
7. Primary Power = _____
8. Secondary Power = _____

b.

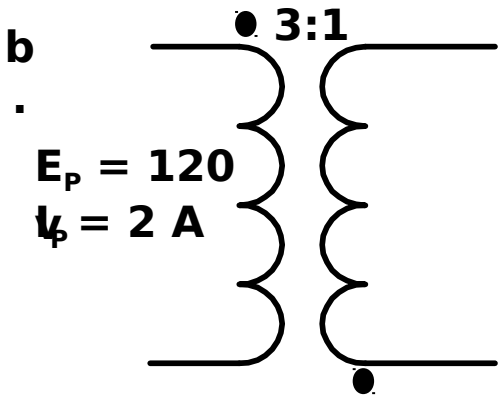


Figure 2

1. Phase relationship = _____
2. Type of Core = _____
3. Turns Ratio = _____
4. Step Up/Down = _____
5. Secondary Voltage = _____
6. Secondary Current = _____
7. Primary Power = _____
8. Secondary Power = _____

C.

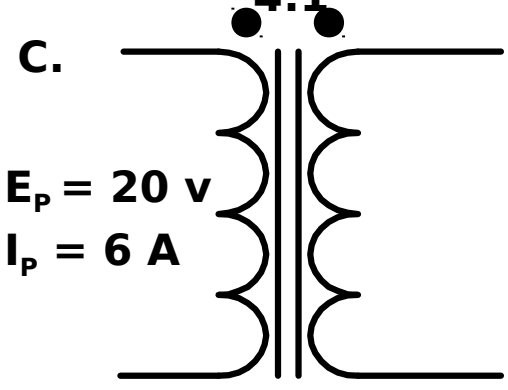


Figure 3

1. Phase relationship = _____
2. Type of Core = _____
3. Turns Ratio = _____
4. Step Up/Down = _____
5. Secondary Voltage = _____
6. Secondary Current = _____
7. Primary Power = _____
8. Secondary Power = _____

AC: Transformers

JOB: 2 **Solve for turns ratio, primary and secondary Voltages, Current & Power.**

d.

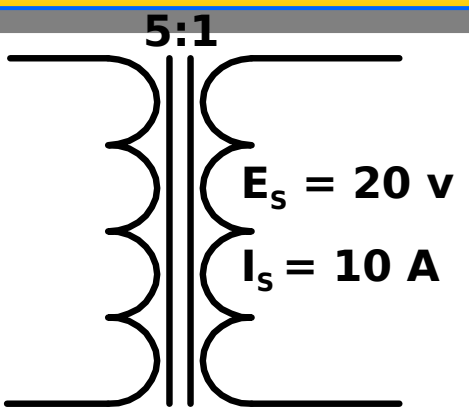


Figure 4

1. Phase relationship = _____
2. Type of Core = _____
3. Turns Ratio = _____
4. Step Up/Down = _____
5. Primary Voltage = _____
6. Primary Current = _____
7. Primary Power = _____
8. Secondary Power = _____

e.

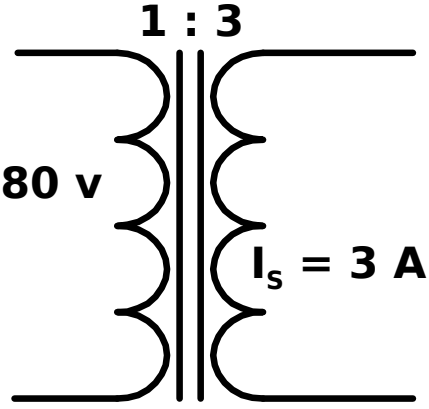


Figure 5

1. Phase relationship = _____
2. Type of Core = _____
3. Turns Ratio = _____
4. Step Up/Down = _____
5. Secondary Voltage = _____
6. Primary Current = _____
7. Primary Power = _____
8. Secondary Power = _____

f.

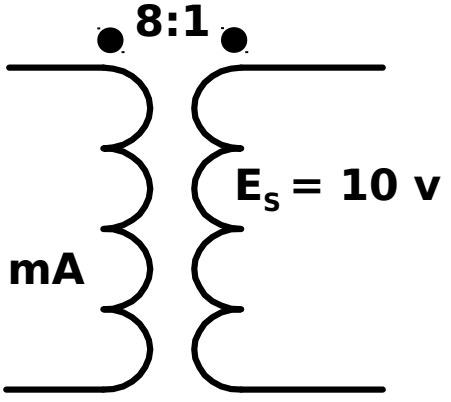


Figure 6

1. Phase relationship = _____
2. Type of Core = _____
3. Turns Ratio = _____
4. Step Up/Down = _____
5. Primary Voltage = _____
6. Secondary Current = _____
7. Primary Power = _____
8. Secondary Power = _____

SLIDE; 30-31, 32-33, 34-35,

AC: Transformers

SUMMARY :

Self induction means the opposing flux lines cut across the coils producing counter electromotive force, such as in the Autotransformer.

Mutual induction in one coil induces a voltage in another coil by its flux lines cutting across the windings of the second coil.

Primary Winding The coil generating the flux lines.

Secondary Winding The coil in which the flux lines are inducing a voltage.

Iron core Frequencies 20KHz and below, [Power Transformers].

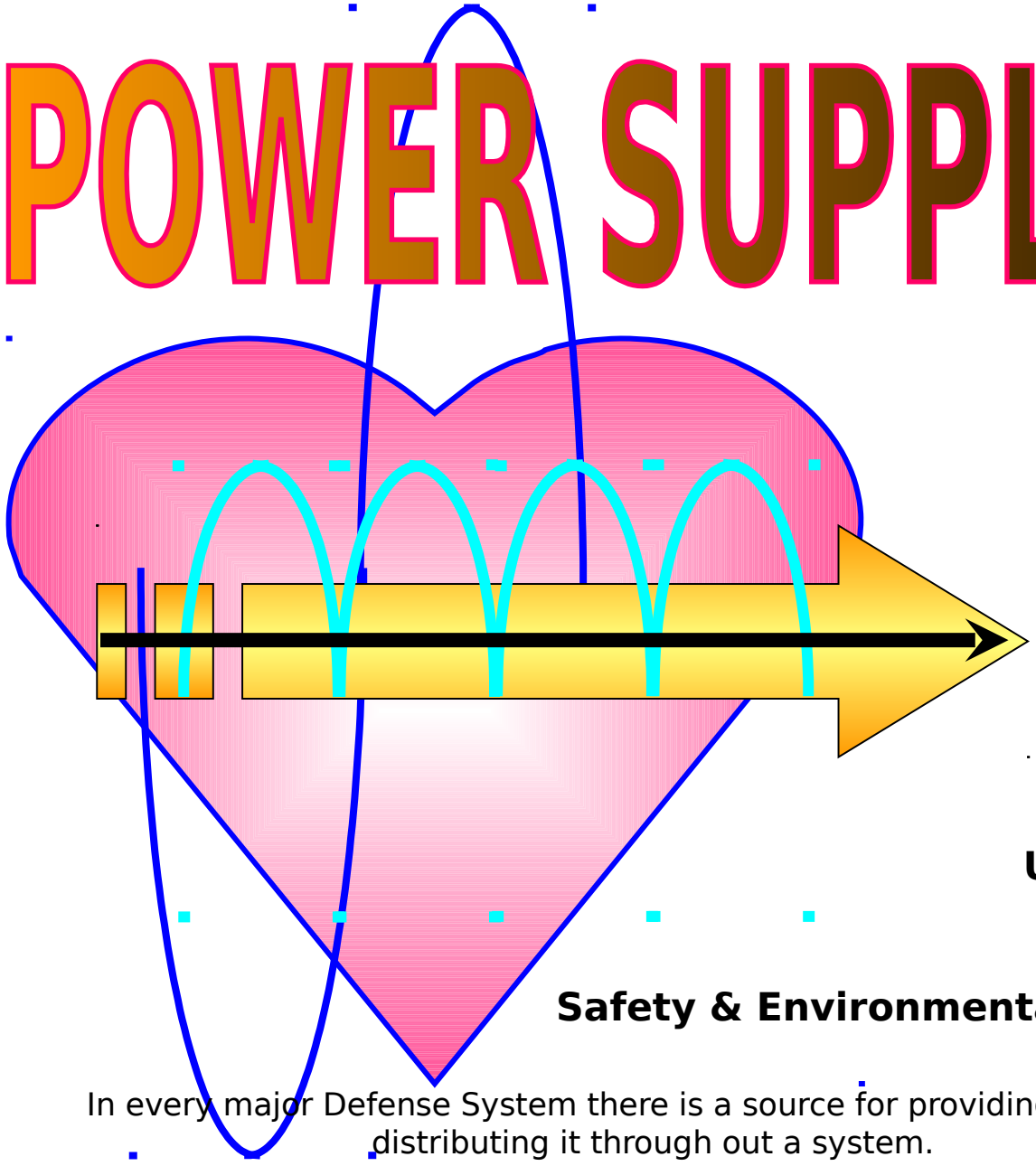
Air core 20KHz and above.

Phase; Transformer can be 180 degrees out of phase or in phase by reversing the winding process on the secondary.

Power in the primary is always equal to the power in the secondary.

AC:

BASIC POWER SUPPLIES



Unclassified

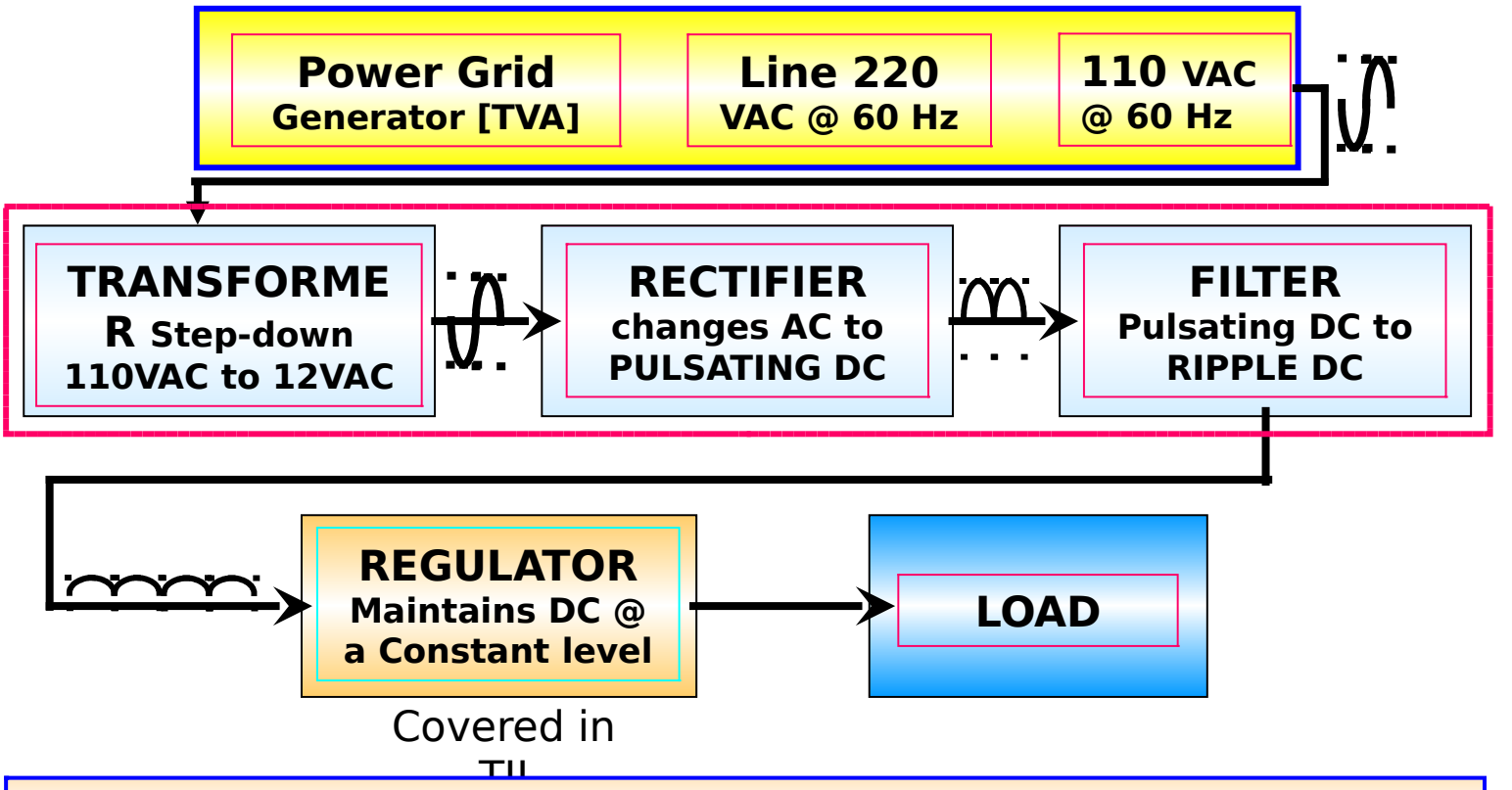
Safety & Environmental Impact is LOW

In every major Defense System there is a source for providing power and distributing it through out a system.

Therefore the power supply can easily be thought of as the heart of a system. It will be one of the first checks made in Maintenance. It makes good sense & good maintenance procedure to to ensure that the voltages applied are correct before looking elsewhere for a malfunction.

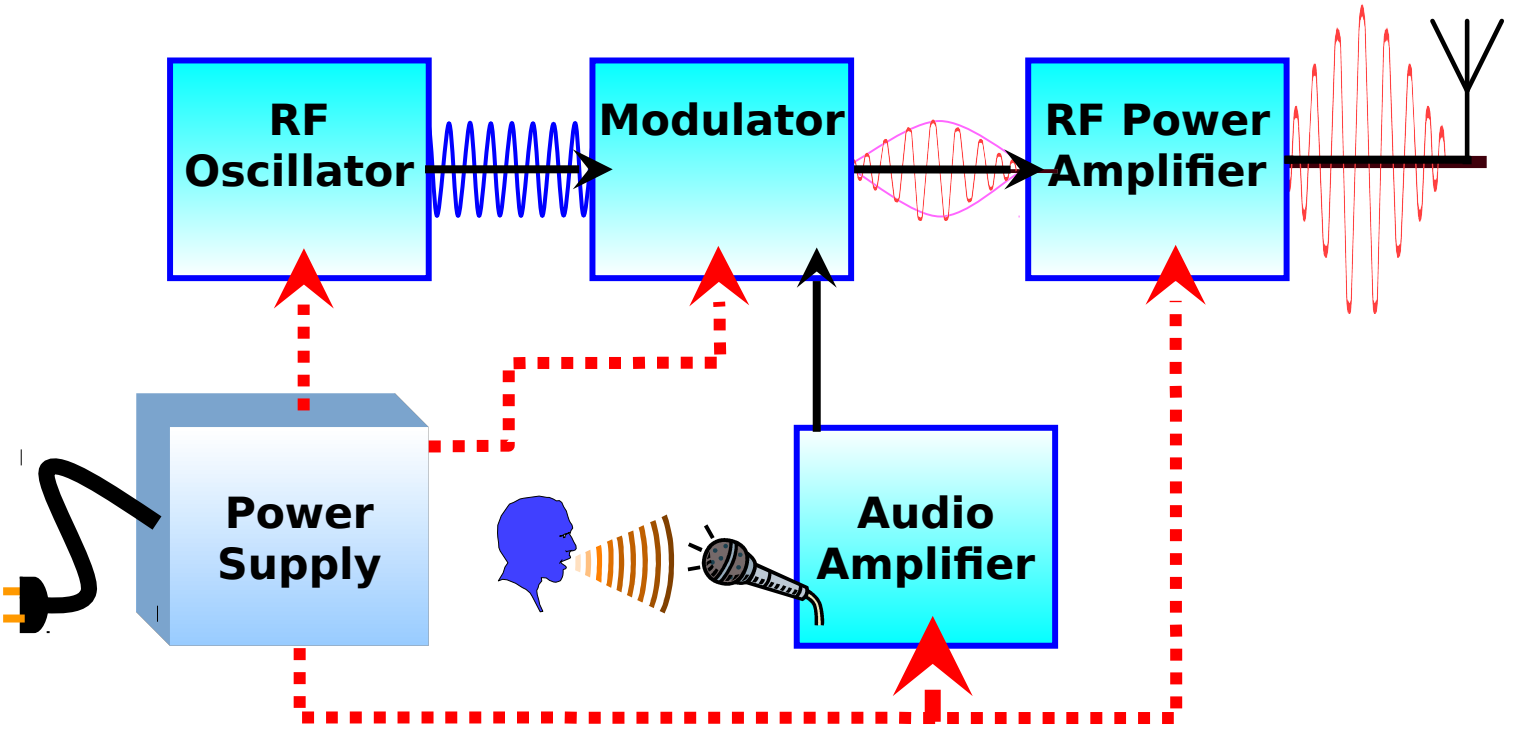
AC: Power Supplies; Overview

Block Diagram:



Covered in
TU

Block Diagram: Radio Transmitter Group, A typical use.



AC: Power Supplies; Overview

Terms:

Power Supply;

Changes the AC Line Voltage to the required DC operating Voltages for the designated equipment. It can be + or – or both.

Rectifier;

Changes the AC output of the Transformer to "PULSATING DC".

+ or – Half wave

+ or – Full wave

Allows Current to flow in 1 direction, It acts like a one way valve, or one way Current device.

Semiconductor Diode: The most common device for Rectifier Ckts.

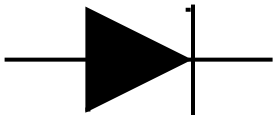
Diode; **Sometimes referred to as a Crystal.**

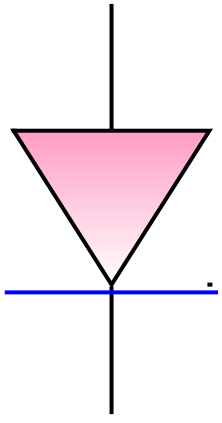
Advantages; Small in size, Low Voltage ops, Uses less power.

Disadvantages; Sensitive to Heat & High Voltage.

Letter Symbol; CR or **D , CR_1, $_2$, $_3$, ...**

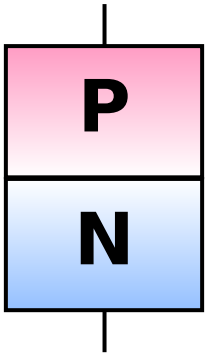
Schematic Symbol;





Positive Material, ANODE

Negative Material, CATHODE



AC: Power Supplies; Diodes

BIAS: 2 states of operation, Forward & Reverse Bias

Bias;

Is the Difference of Potential between 2 points or Elements.

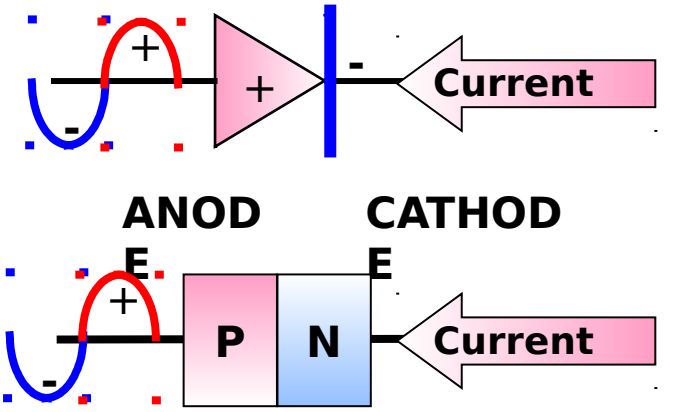
Forward Bias;

When the Polarity of the Signal agrees w/ the Polarity of the material, Current flow is Maximum, Resistance is Minimum.

The Positive alternation Agrees w/ the Positive Material, [Anode]

The Diode is Forward Biased.

Diode is ON.



Note:

Current Flows against the Arrowhead, to the most positive point in the Ckt.

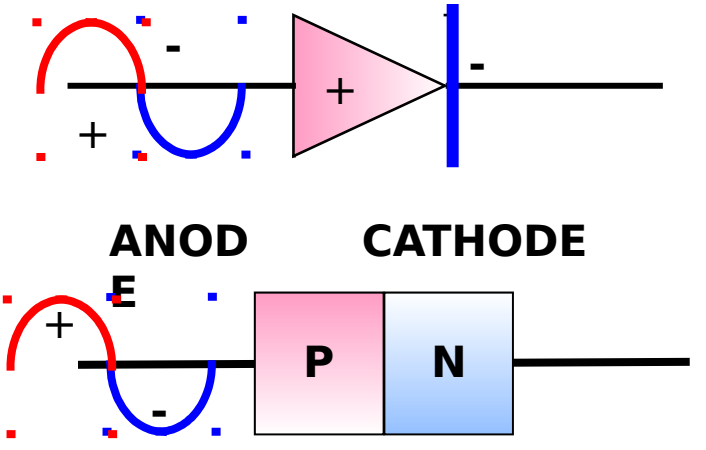
Reverse Bias :

Reverse Bias;

When the Polarity of the Signal "Disagrees" w/ the Polarity of the material, Current flow is Minimum, Resistance is Maximum.

The Negative alternation Disagrees w/ the Positive Material, [Anode]

The Diode is Reversed Biased.



Note:

Current Flow is Minimum.

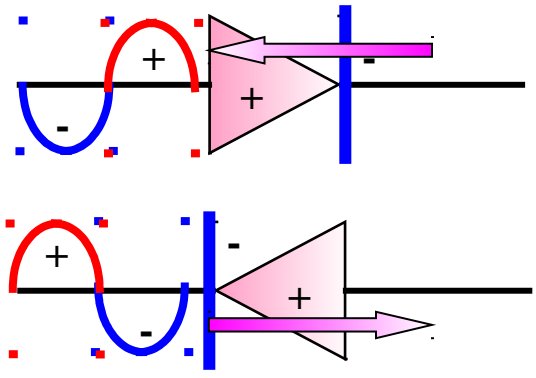
Resistance is Maximum.

Diode is OFF.

BIAS: Forward & Reverse Bias

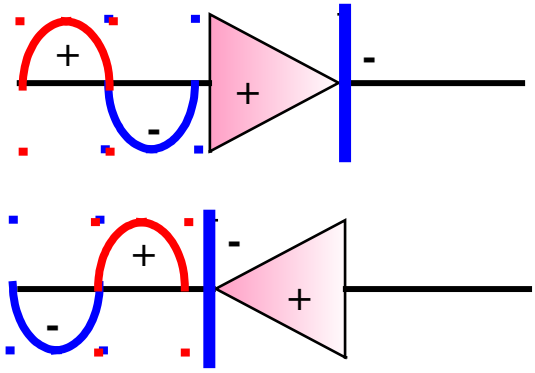
Forward Bias;

When the Polarity of the Signal "agrees" w/ the Polarity of the material,
Current flow is Maximum,
Resistance is Minimum.



Reverse Bias;

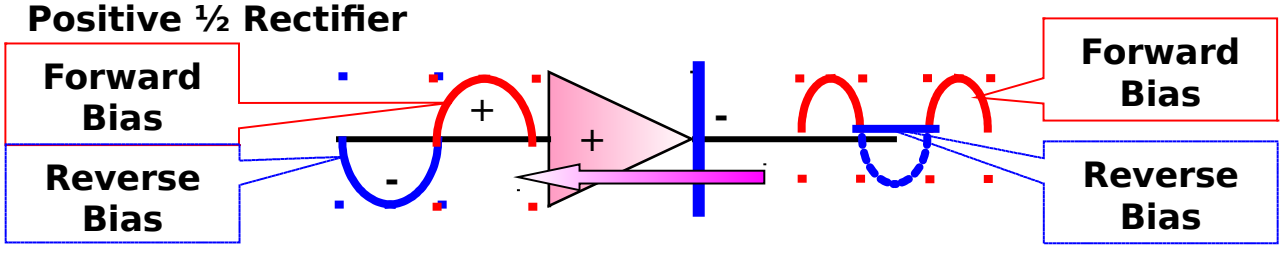
When the Polarity of the Signal "Disagrees" w/ the Polarity of the material,
Current flow is Minimum,
Resistance is Maximum.



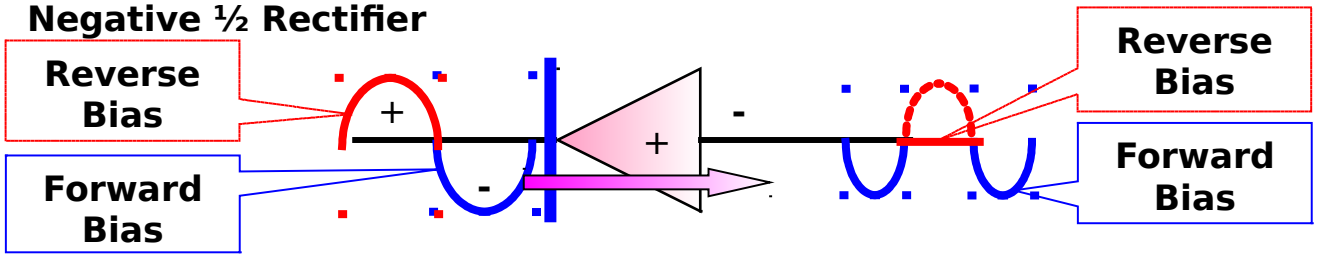
2 Types of ½ Wave Rectifiers: Positive & Negative

Positive & Negative ½ Wave; The position of the Diode in respect to the input will determine the polarity of the output, when the diode is forward biased. 1 diode makes it a ½ Rectifier. Frequency in = Frequency out.

Positive ½ Rectifier



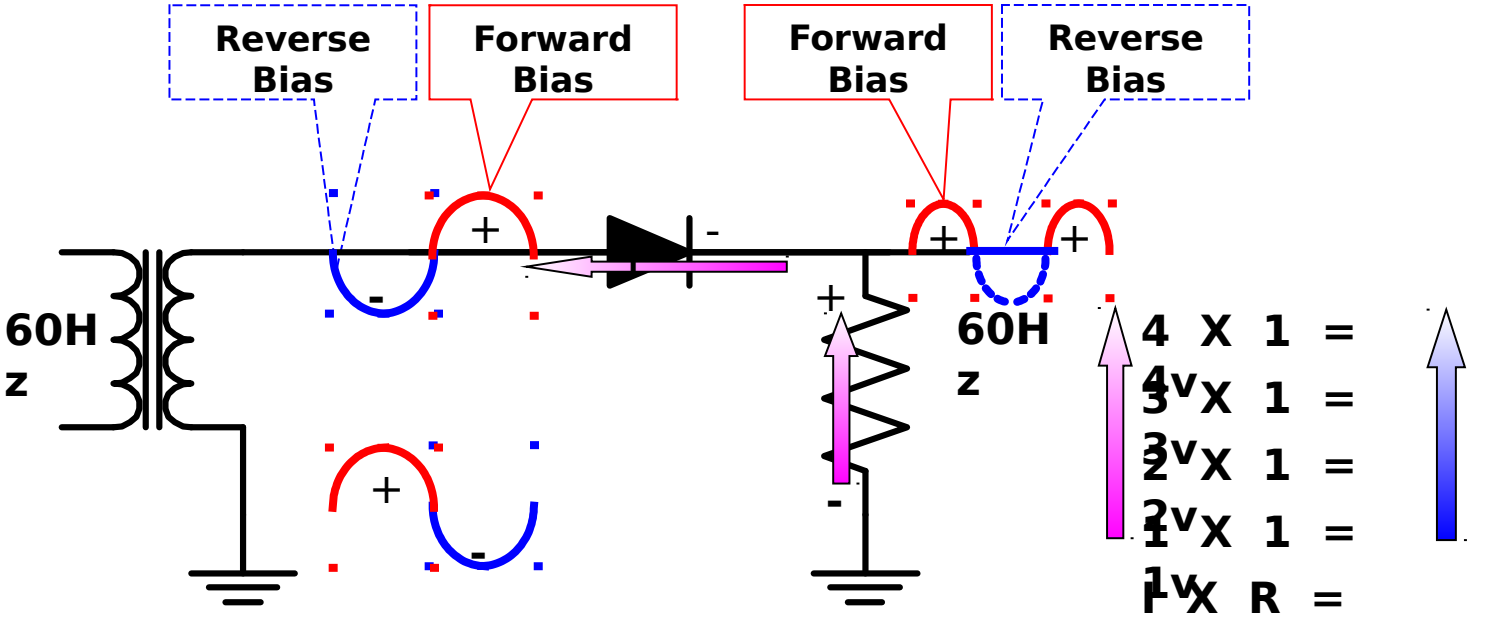
Negative ½ Rectifier



AC: Power Supplies; ½ Rectifier

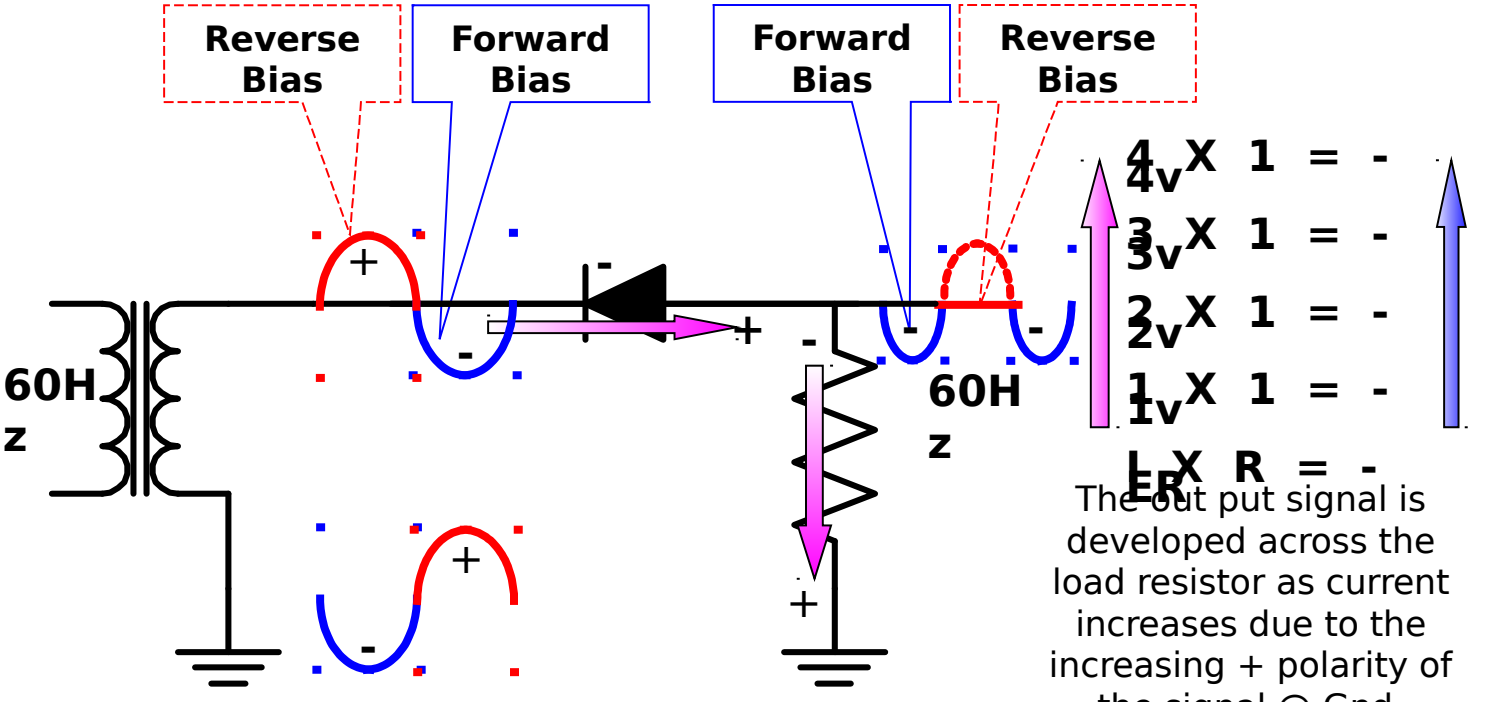
Positive ½ Wave Rectifier:

Increasing Forward Bias Increases Current flow through a fixed value of resistance thus an increasing voltage drop is developed on the output.



The out put signal is developed across the load resistor as current increases due to the increasing + polarity of the signal.

Negative ½ Wave Rectifier:

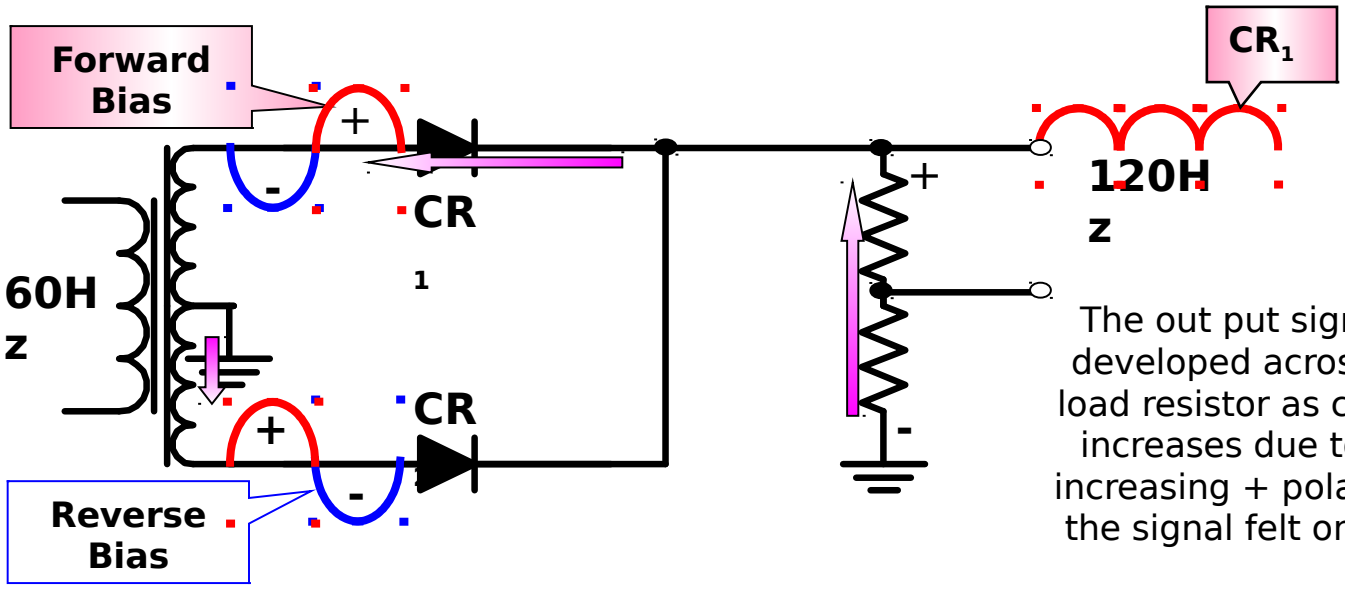


The out put signal is developed across the load resistor as current increases due to the increasing + polarity of the signal @ Gnd.

AC: Power Supplies; Full Wave Rectifier.

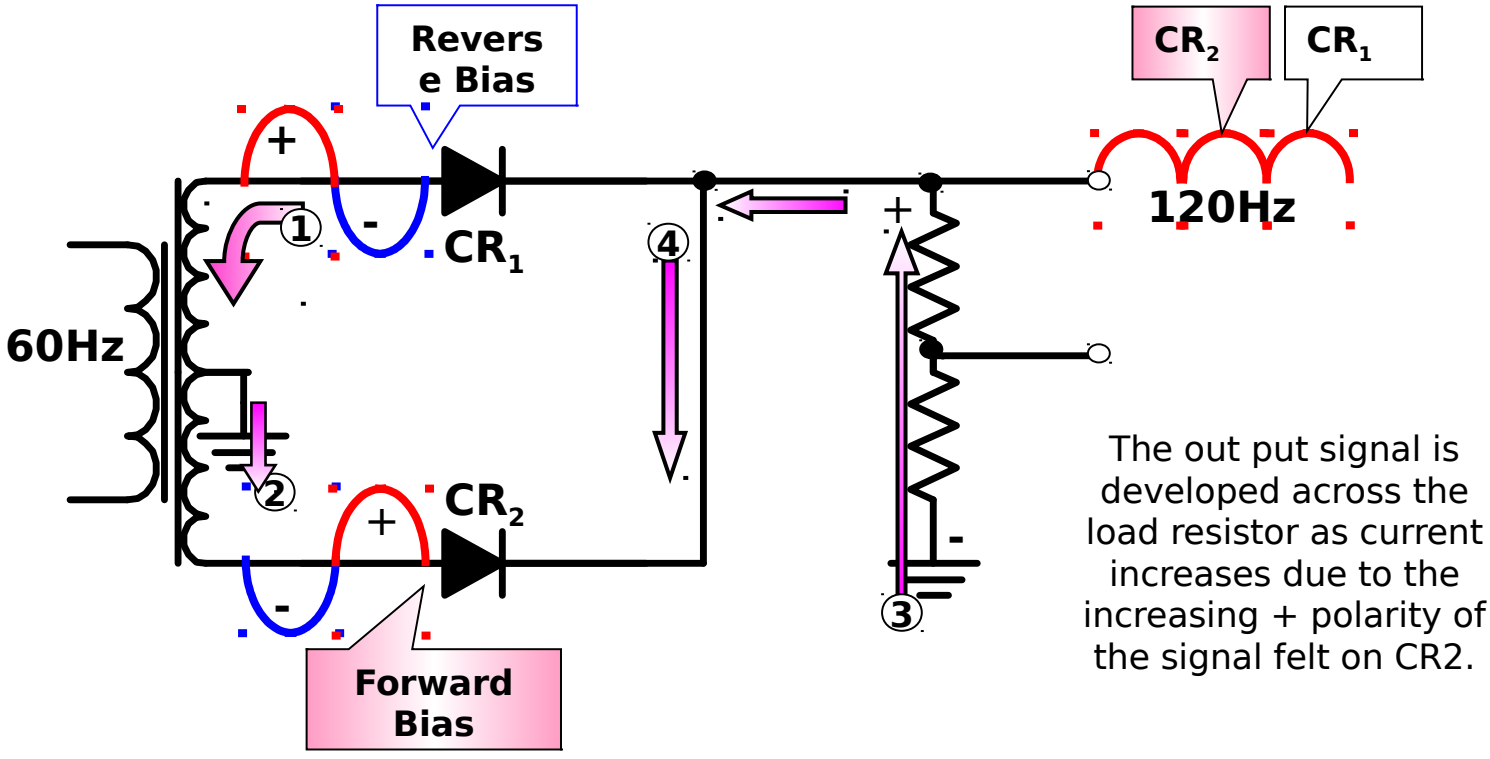
Positive Full Wave Rectifier: CR1 conducts.

The Full Wave is identified by two diodes, position of the diode in ref to direction of the input signal describes the output polarity. Only one diode conducts @ a time, Output freq is twice the input.


Forward Bias
CR1
60Hz
CR
Reverse Bias
120Hz
The out put signal is developed across the load resistor as current increases due to the increasing + polarity of the signal felt on CR1.

Note: Center tap transformer allows for two voltages the same but of opposite

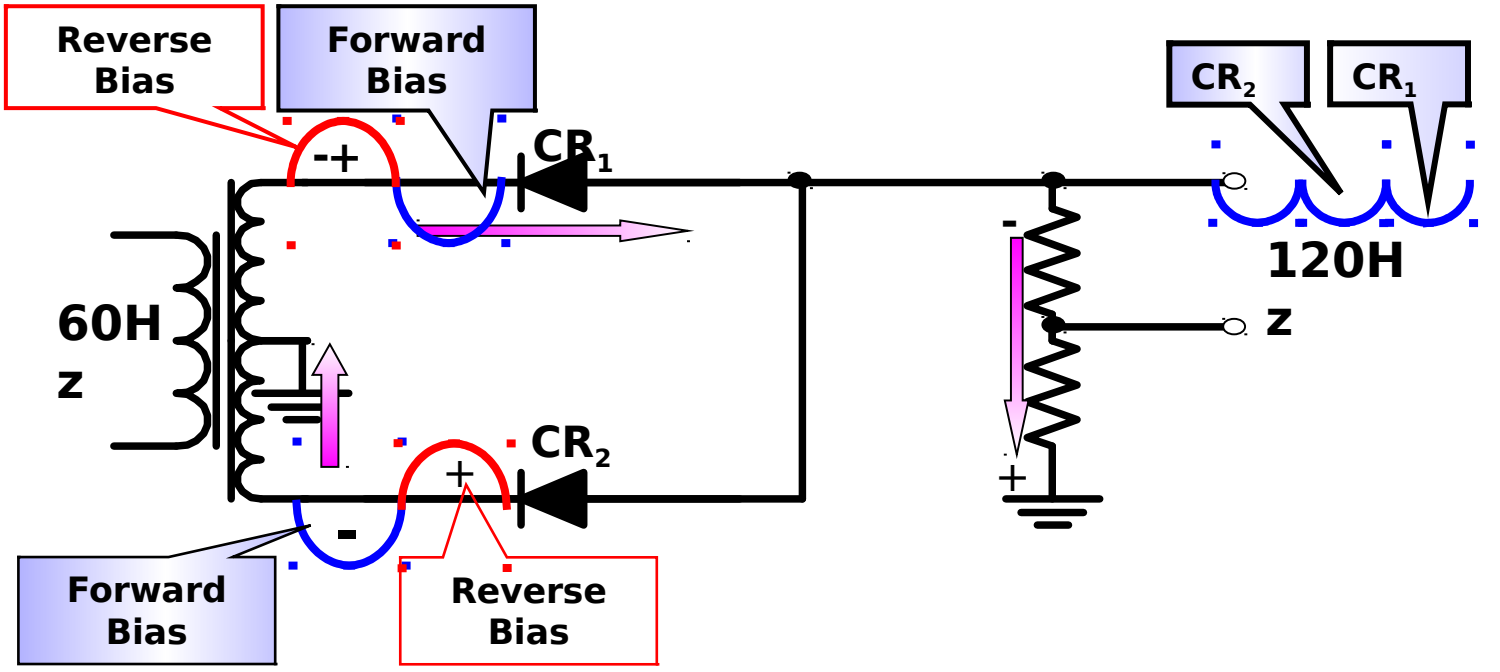
CR2 conducts.


Reverse Bias
CR1
CR2
60Hz
120Hz
Forward Bias
The out put signal is developed across the load resistor as current increases due to the increasing + polarity of the signal felt on CR2.

AC: Power Supplies; Full Wave Rectifier.

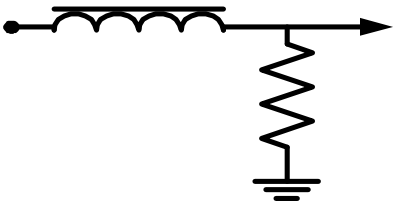
Negative Full Wave Rectifier:

The Negative Full Wave is identified by the position of the diode in ref to direction of the input signal. The position describes the output polarity. Only one diode conducts @ a time. Output freq is twice the input.

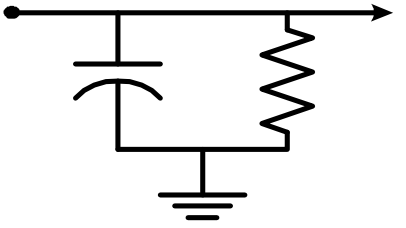


Filters types:

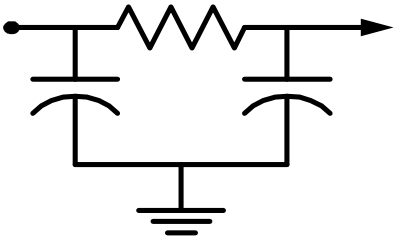
The Filter converts pulse-sating DC from the rectifier, to Ripple DC & raises the DC voltage level.



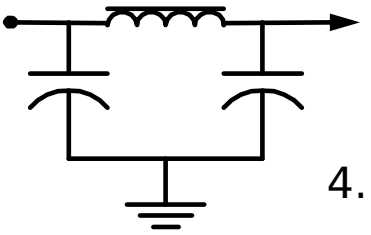
1. LR Inductive input Filter



2. RC Filter



3. RC pi

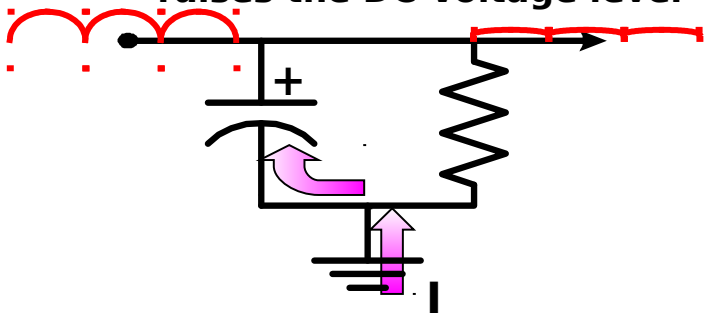


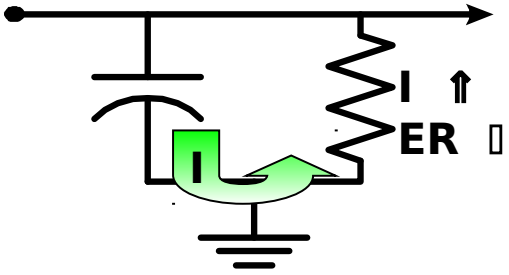
4. LC pi Filter

Filters RC: Most common type of filter, inexpensive.

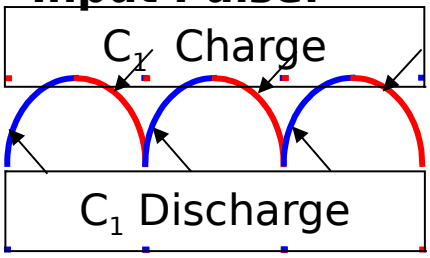
RC Filter, <u>Quick charge</u>, no opposition to current in the path of charge.

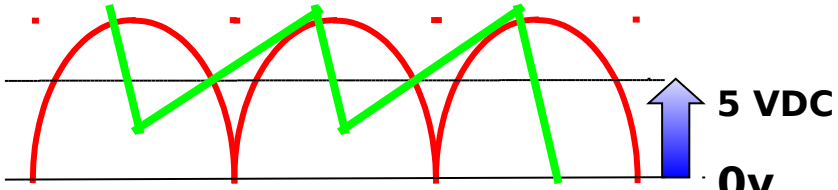
<u>Slow discharge</u>, through the resistor. Effectively fills the gap between the pulses. [fills in the speed bumps]. Reduces ripple & raises the DC Voltage level





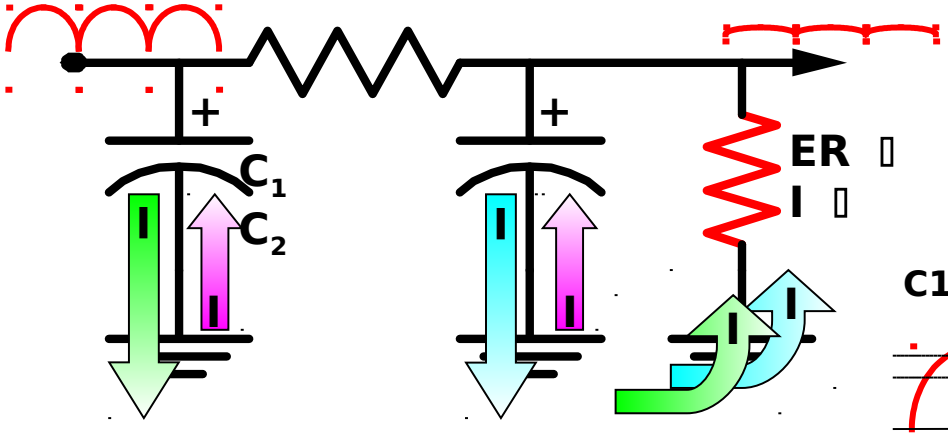
Input Pulse:



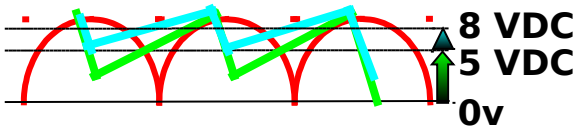


C1 Discharge Effect

Filter, RC Pi : Better version of the RC type



C1 & 2 Discharge Effect



<u>RC Pi Filter</u>, <u>quick charge</u>, <u>Slow discharge</u>.

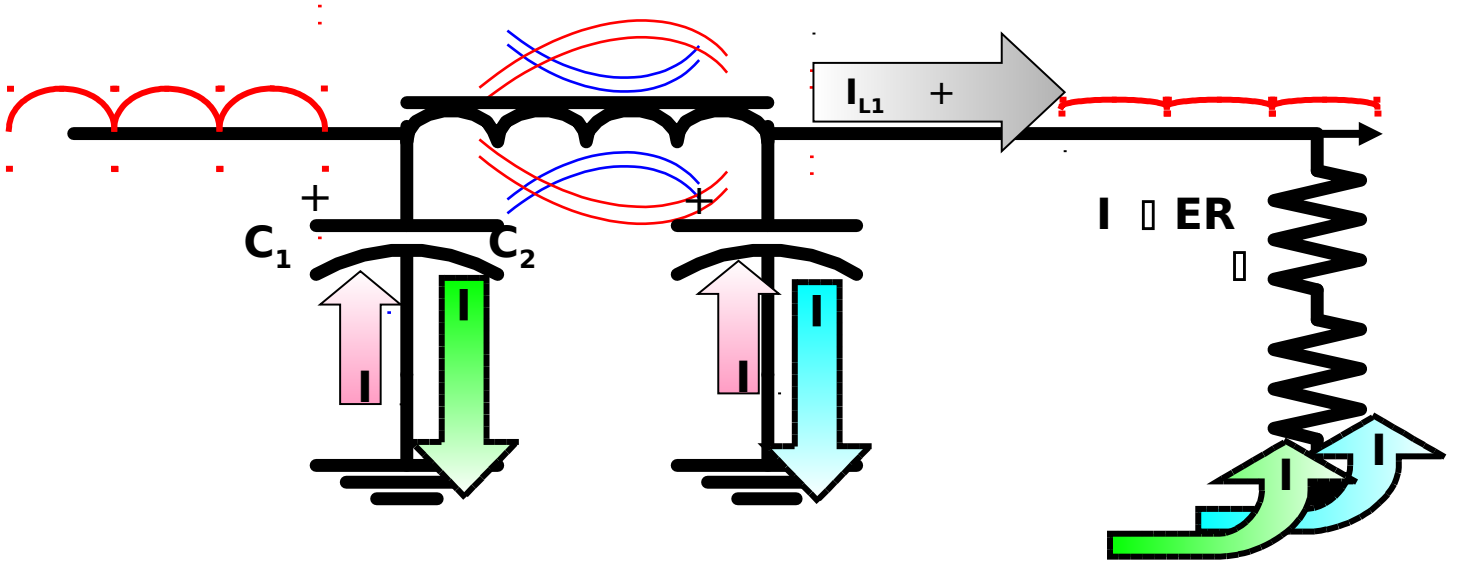
2 Caps raise the DC Level & Reduces the Ripple even better than One.

AC: Power Supplies; Filters.

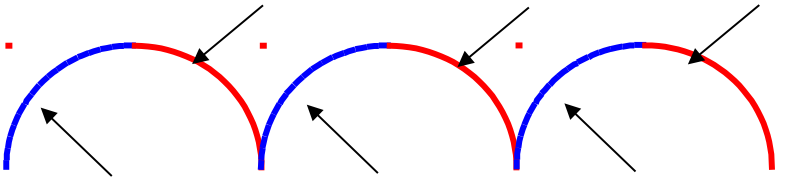
Filter, LC Pi : Best Filter

LC Pi Filter, C_1 & $_2$ Quick charge, Slow discharge, through the resistor.

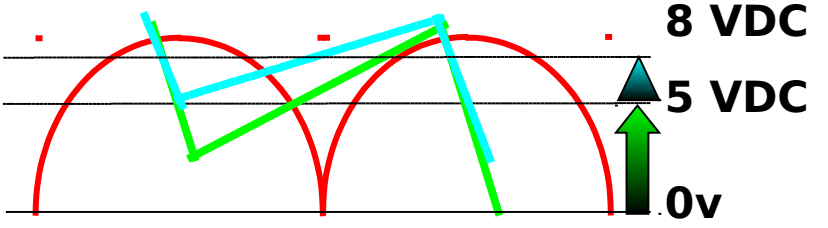
When C1 & 2 discharges across the load resistors the most + point in the Ckt is at the top of the load resistors, current from L1 will flow toward that +, L1 is acting like a choke, keeping current from flowing back to the rectifier. The new DC applied is now established.



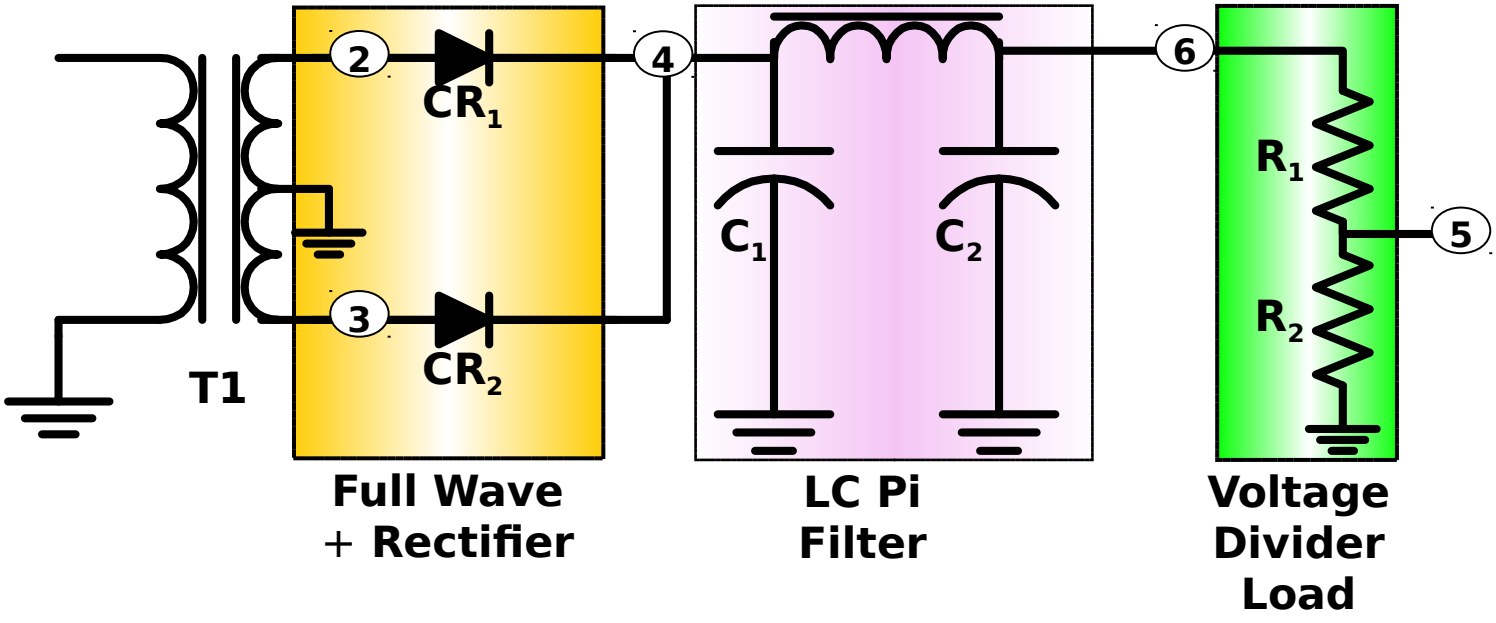
Input Pulse:



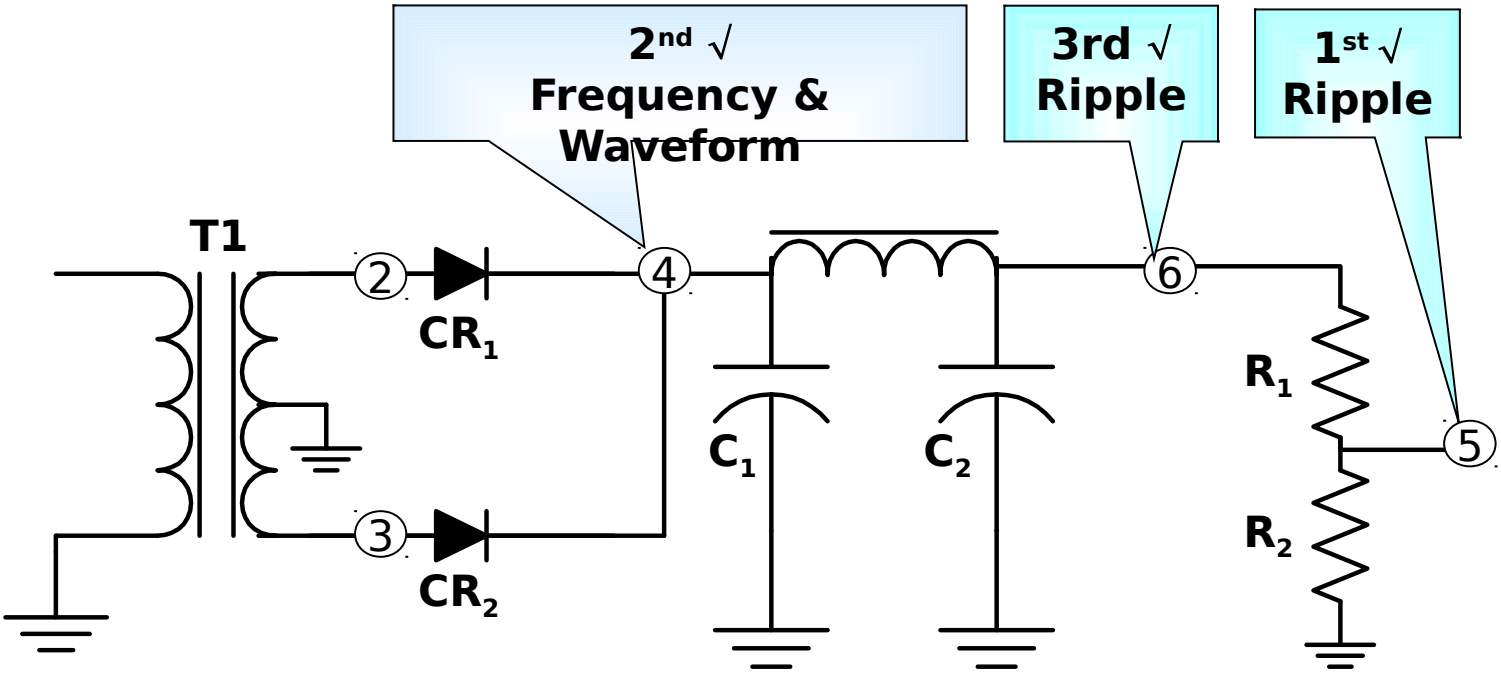
C1 & 2 Discharge Effect



Circuits : Individual Ckts Divide the Power Supply.

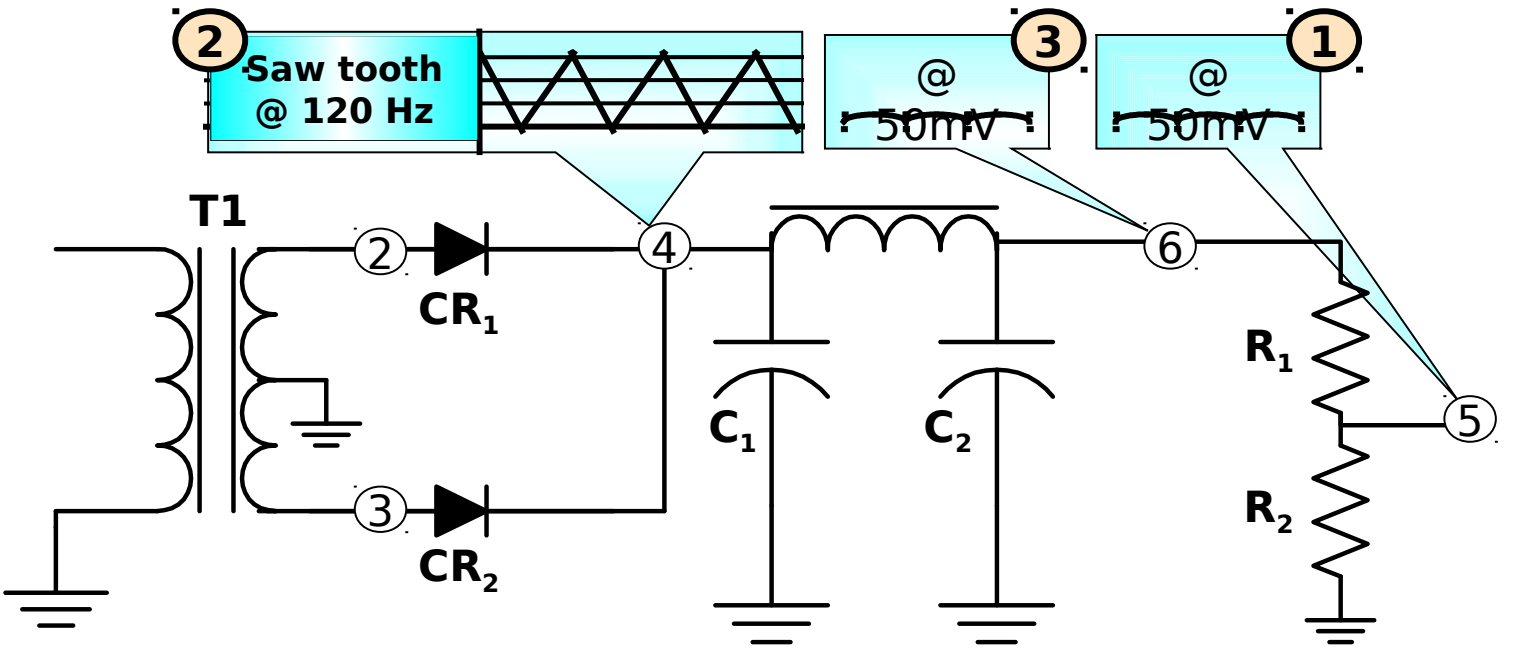


½ Method : Test Point Check sequence.

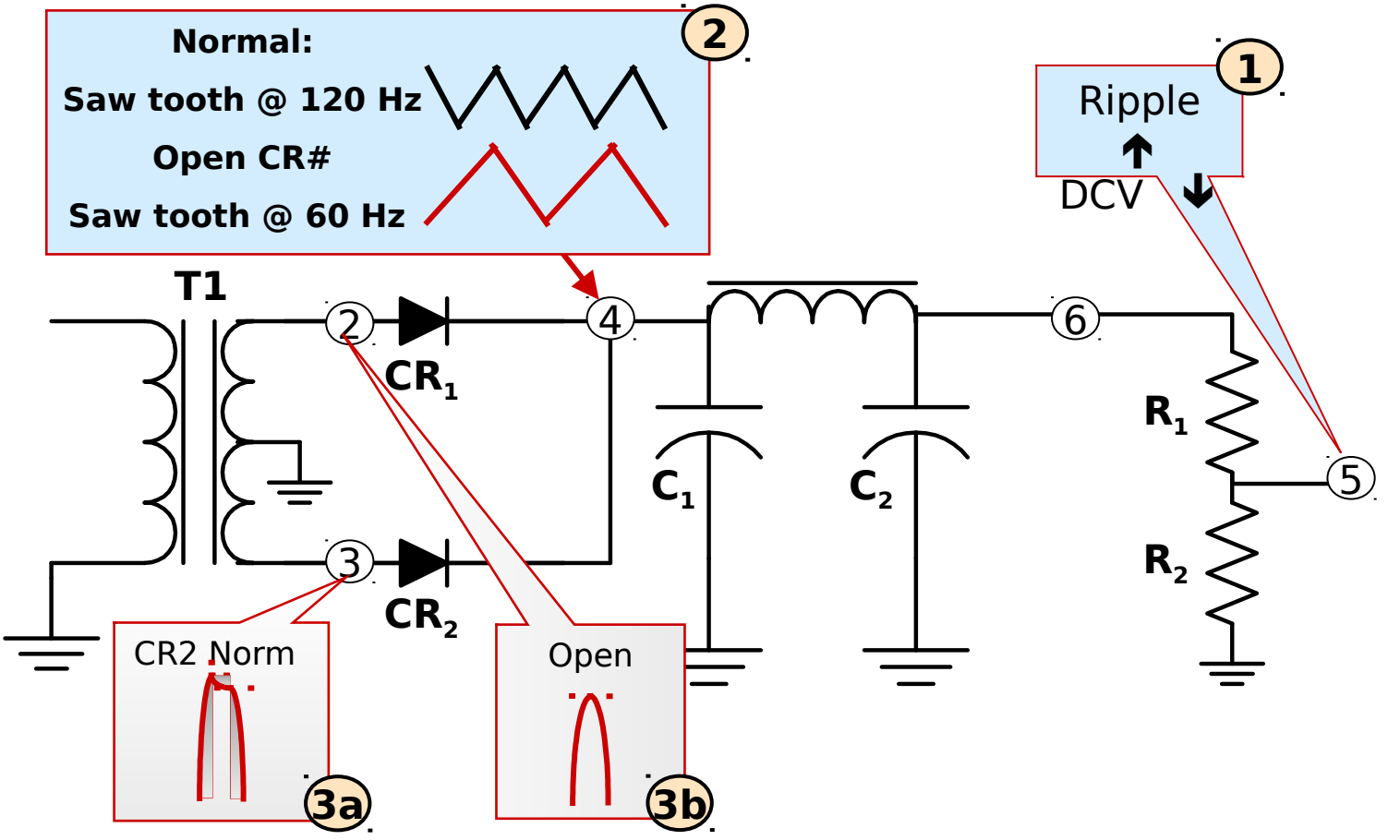


AC: Power Supplies; PC-82.

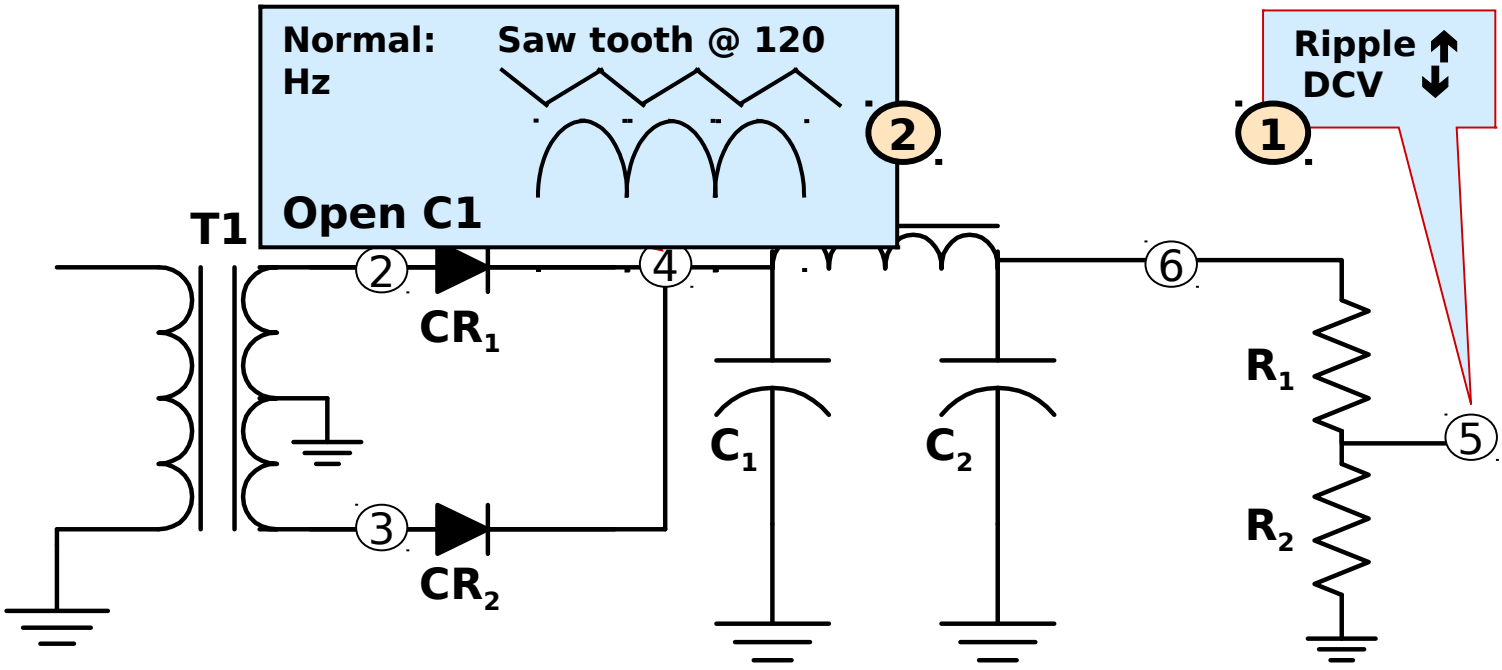
½ Split Method : Normal Signals.



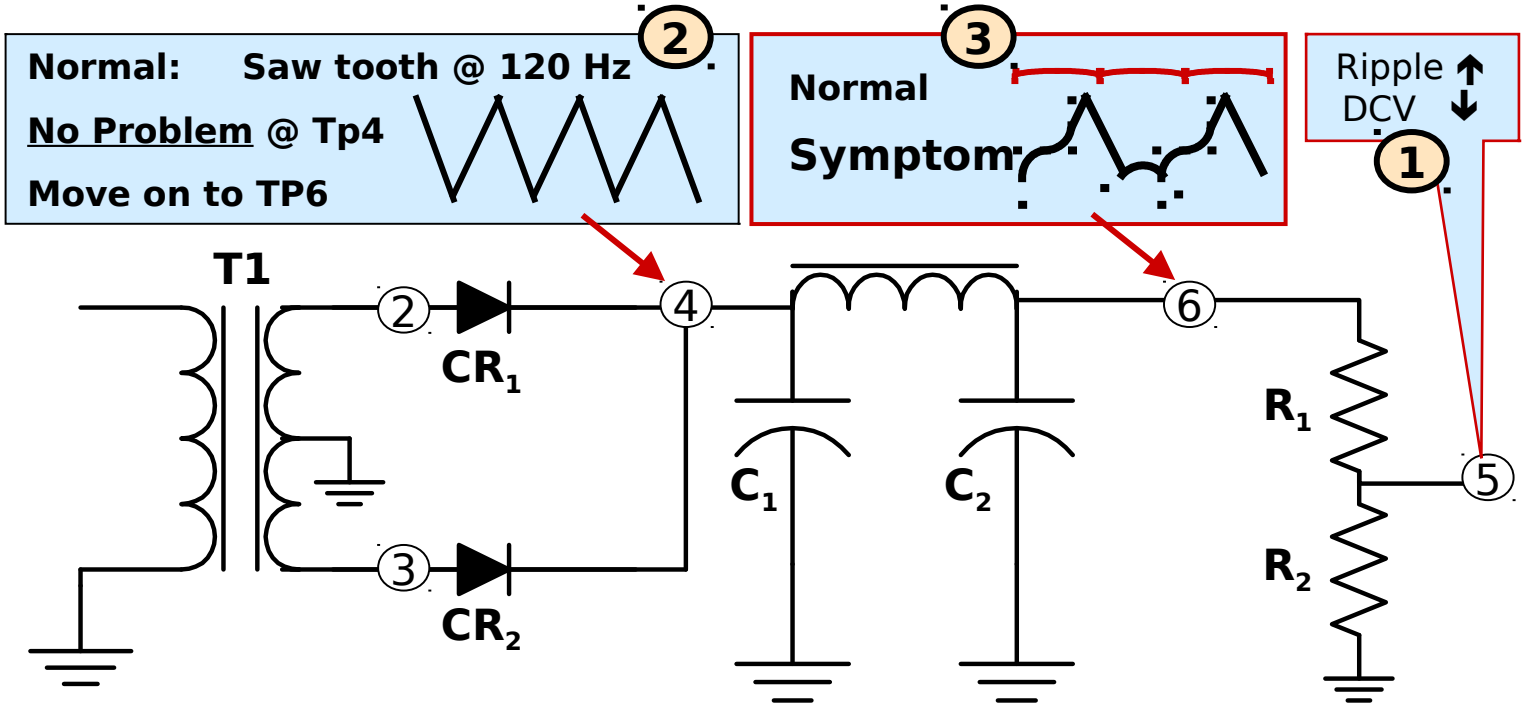
½ Split Method : TP4 Analysis, CR# Open.



½ Split Method : TP4 Analysis, C1 OPEN.

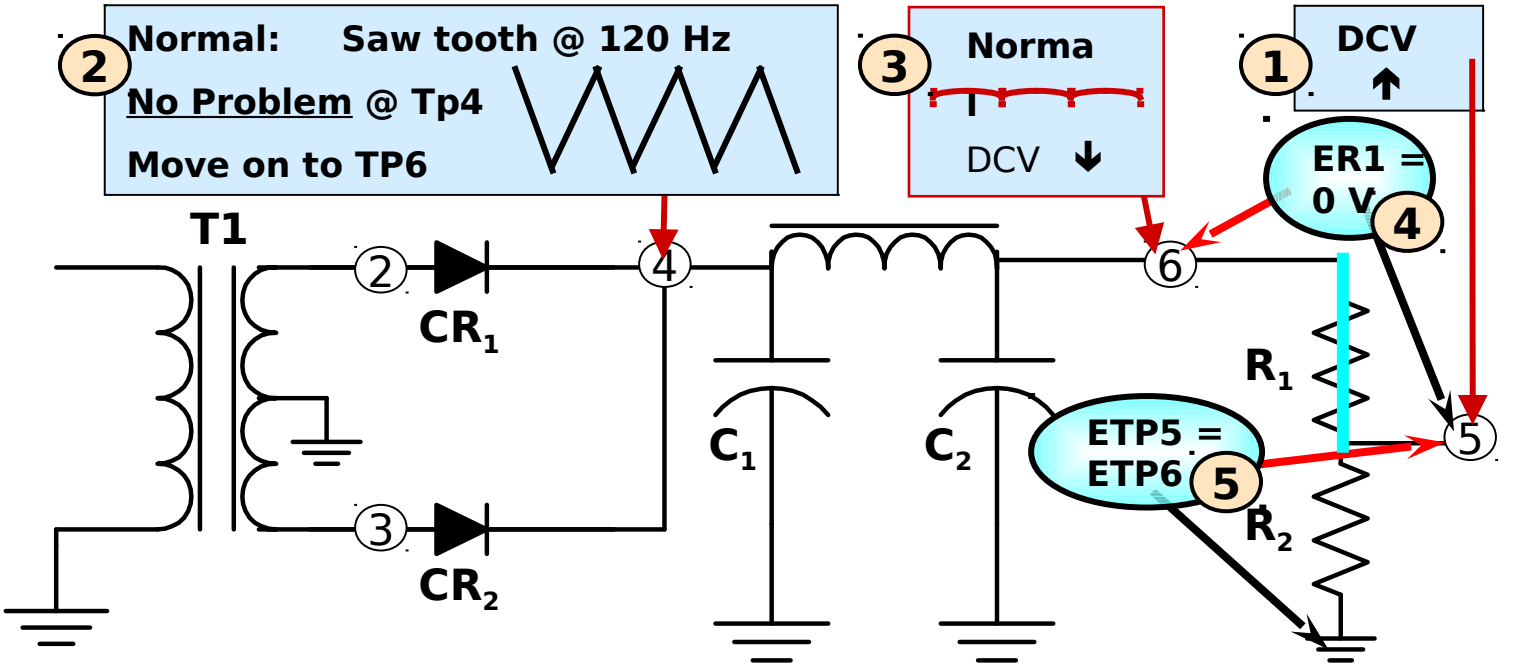


½ Split Method : TP6 Analysis, C2 OPEN.

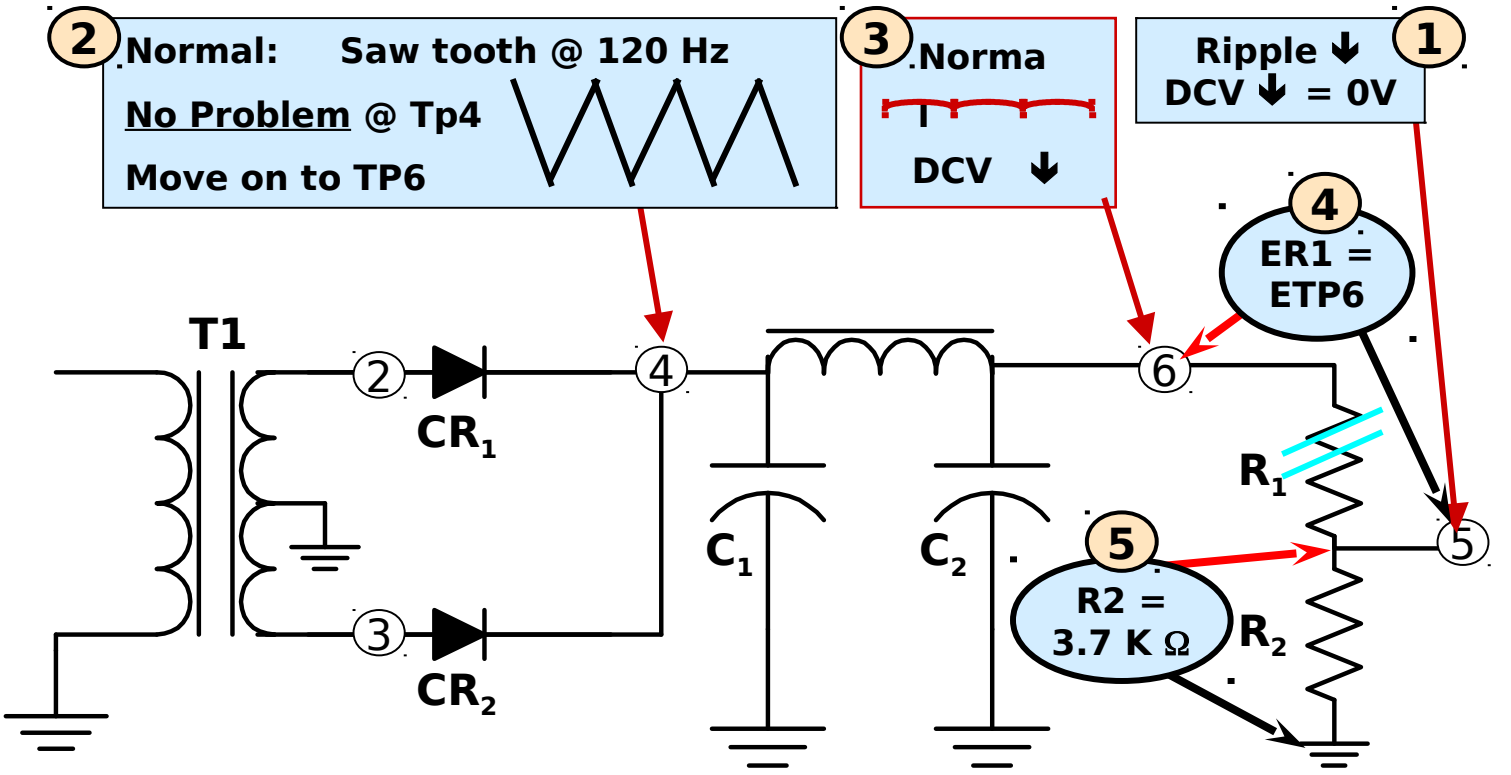


AC: Power Supplies; PC-82.

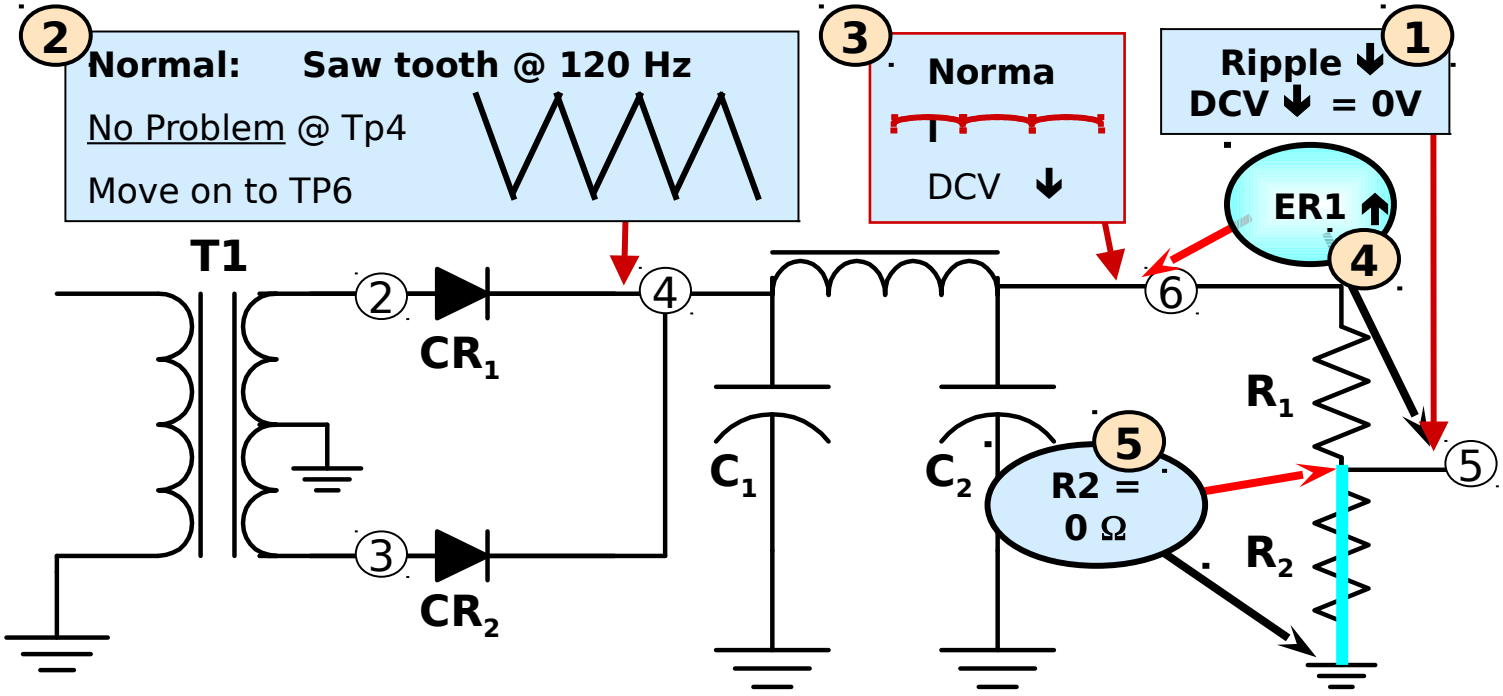
½ Split Method : DC Voltage divider Analysis, R1 SHORT.



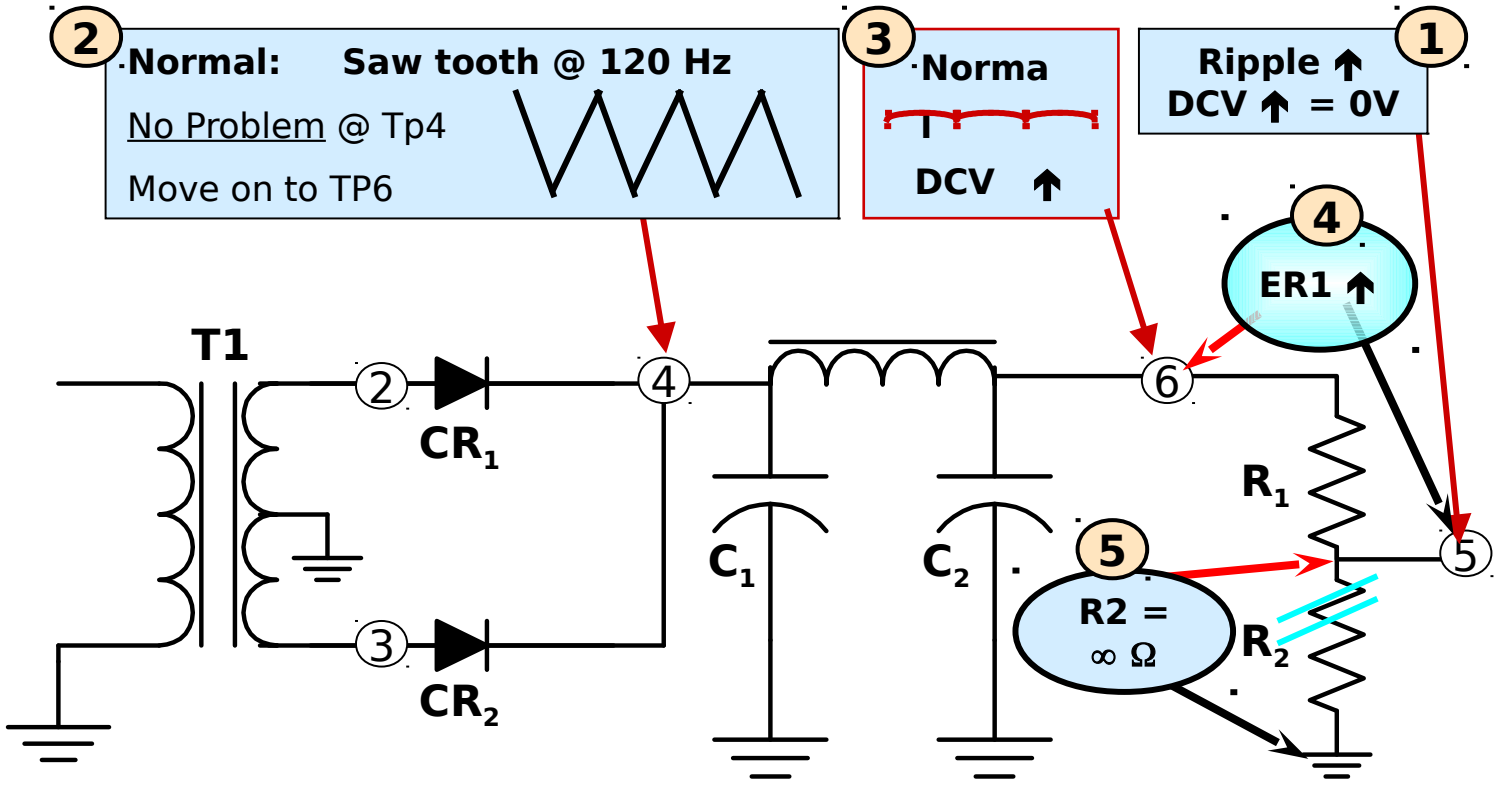
½ Split Method : DC Voltage divider Analysis, R1 OPEN.



½ Split Method : DC Voltage divider Analysis, R2 SHORT.



½ Split Method : DC Voltage divider Analysis, R2 OPEN.



AC: Power Supplies;

PE Setup:

1. **PC 82 card on Pc 1 position, Set S1 ↑ .**
2. **Trainer Pc 1; AC Pwr "ON" {no DC }**
3. **Enter Defaults; F104 & F114. [Must be in the trainer @ all times.]**
4. **Get Normals; TP5, Ripple & DCV**
   TP4, Signal, Freq & DCV
   TP6, Ripple & DCV
   E_{R1}, DCV .

   } Troubleshooting Order

5. **Shoot Bugs & Record.**

E- 104	**F- 111**
F- 102	**F- 108**
F- 110	**F- 113**

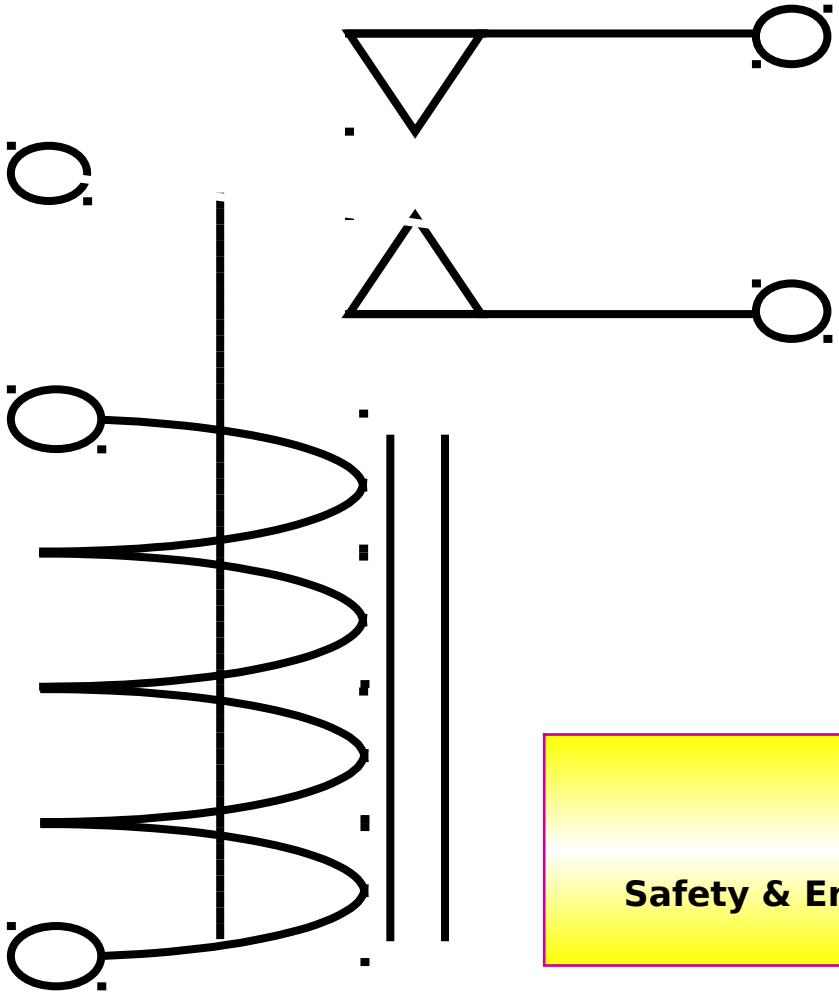
Note:

Turn Trainer Pwr "OFF" @ Breaks.

<u>Reset Trainer after Each & Every Bug</u>.

Reenter; <u>F104 & F114</u> Defaults, then enter new Bug #.

Relays & Switches



UNCLASSIFIED;

Safety & Environmental Impact; LOW

In this lesson the Electro Magnetic Relay & Various types of switches will be examined. These devices are commonly used in all electronics equipment.

AC: Relays & Switches.

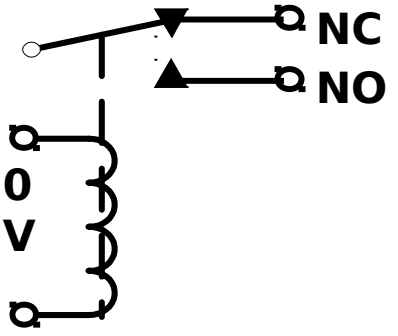
Electromagnetic Relay;

Used for the Routing of Voltage, Current, & Power.

- **W/O Human exposure to high Voltages & Current.**
- **W/1 Switch numerous switches can be Made.**
- **Power up procedures made in sequential order, thus eliminate possible Ckt damage or human error.**
- **Remote location switching made possible.**

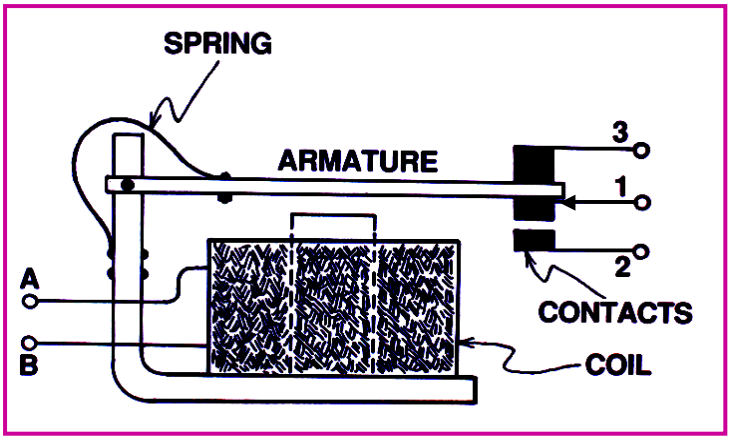
Schematic Symbols;

$K_{1,2}$, ...



Note:

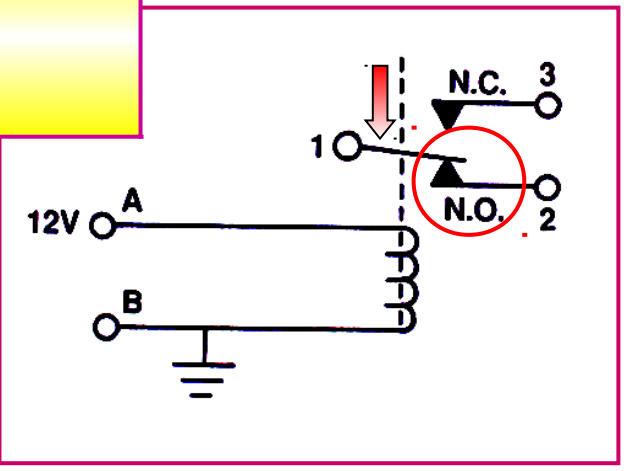
Relays normally drawn De Energized.

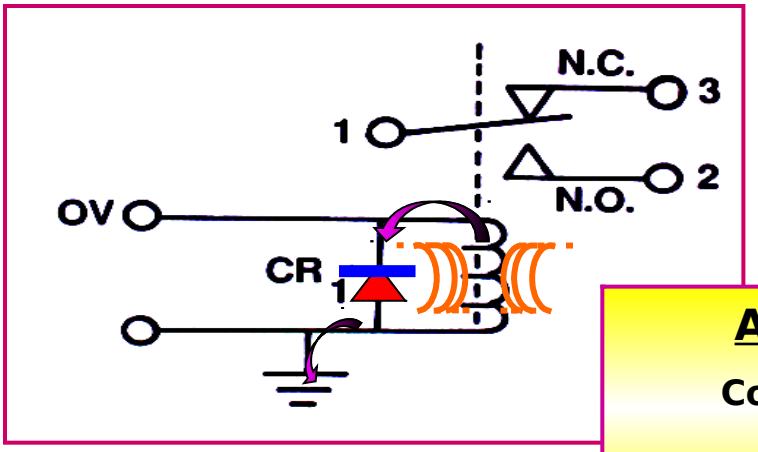


Electromagnetic Relay Energized;

12 **Volts Energizes the coil.**

Contacts 1 & 2 Make [Closed].





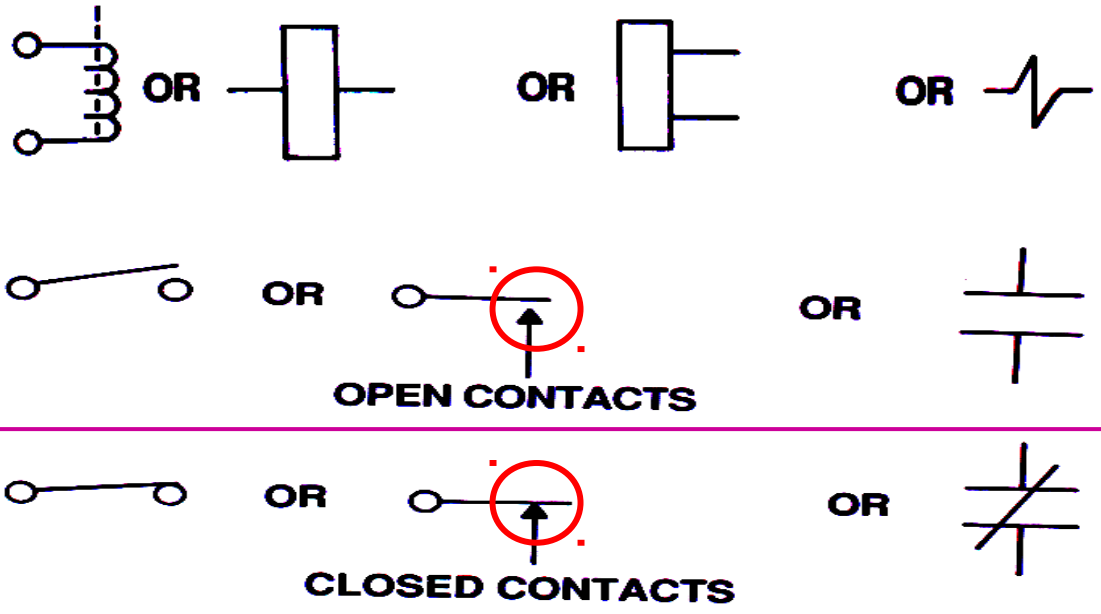
ARC Suppression Diode;

Coil Denergized, Magnetic Field Collapses.

CR1 Forward Bias, Current shunt to Gnd.

AC: Relays & Switches.

Electromagnetic Relay Symbols & Contacts;



Time Delay [Thermal] Relay;

Contacts Make @ a predetermined temperature.

Provide for Ckts to warm-up before full conduction or current flow.

Denergized

Energized

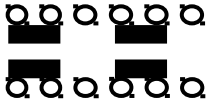
Switch Types;

Interlock Switch

Slide Switch

Single Pole Double Throw

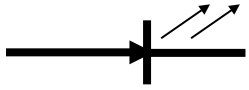
[SPDT]



Slide Switch

4 Pole, Double Throw

[4PDT]



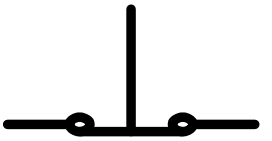
Light Emitting Diode

AC: Relays & Switches.

Switch Types:

Push to Make
[PTM]

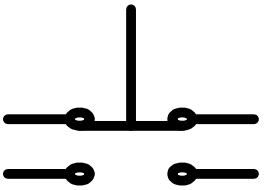
Spring returned



Push to Break

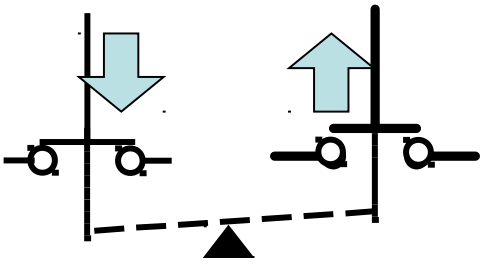
[PTB]

Spring returned



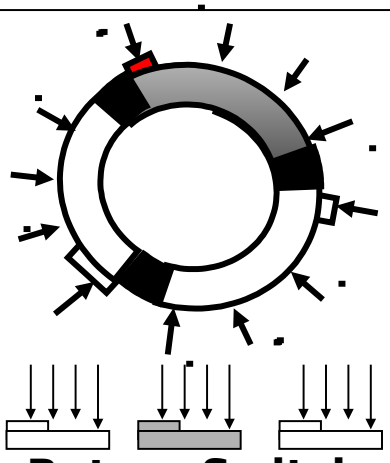
2 Ckt, Push to Break Before Make

Spring returned

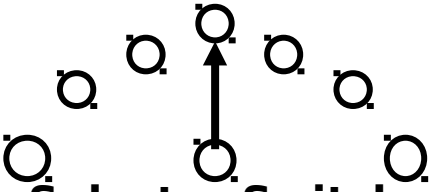


2 Ckt, Push to Break

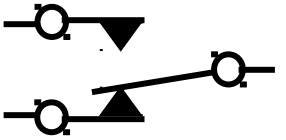
Before Make



Rotary Switch



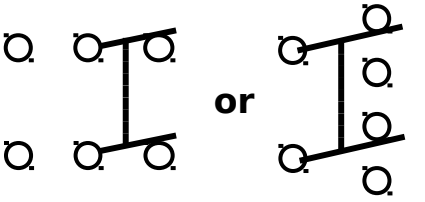
Selector Switch



Toggle Switch

[SPDT]

Single pole Double Throw



Gang Switch

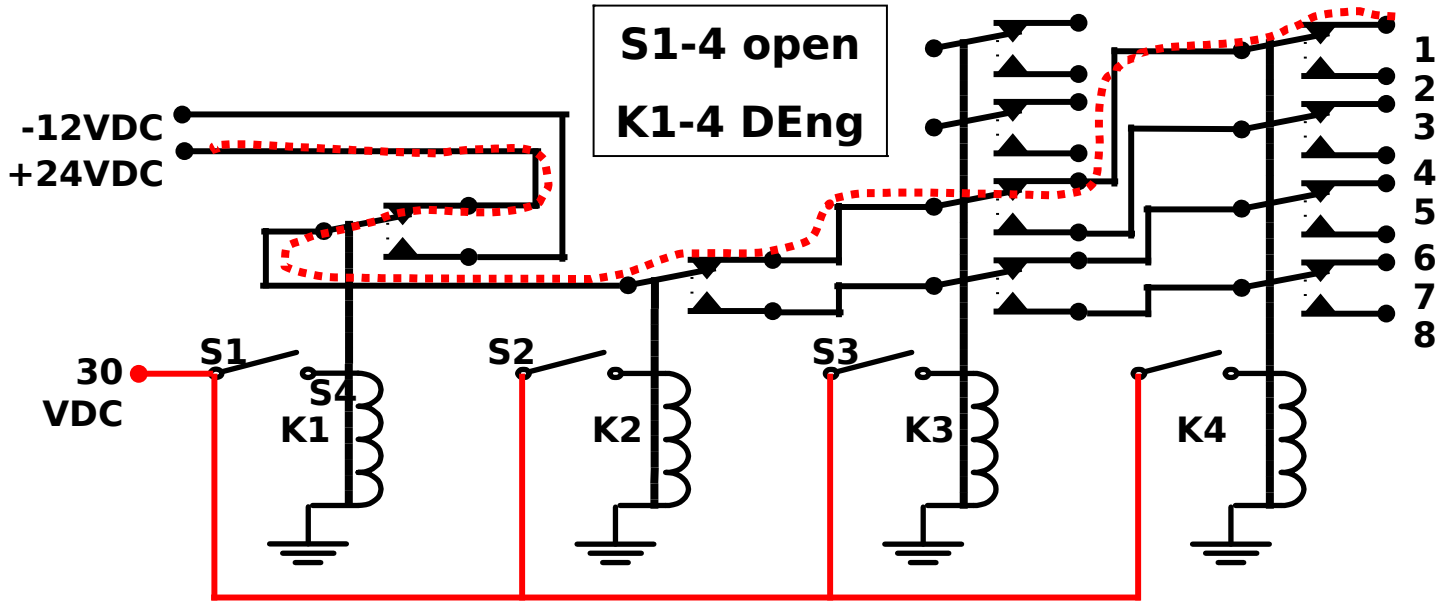
[DPDT]

Double Pole Double Throw

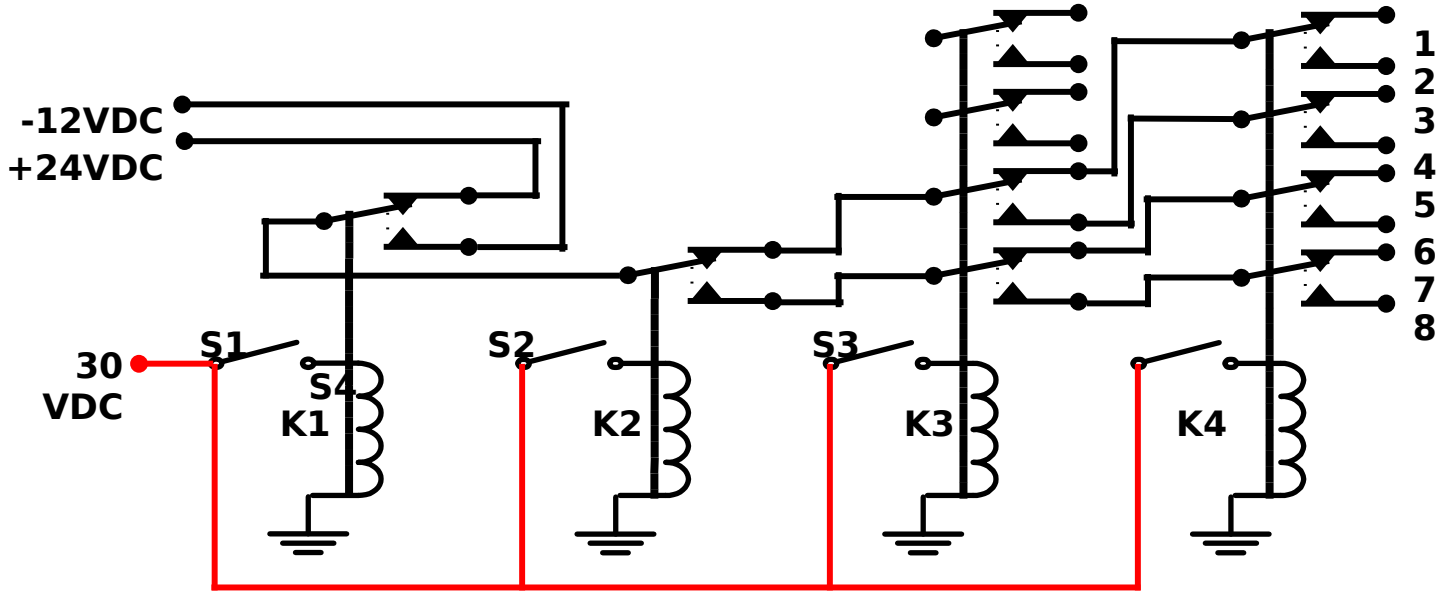
AC: Relays & Switches.

Relay Tree :

Trace the Ckt path to obtain +24V at Pin 1, and indicate the switches that are closed & Relays that are energized.



Relay Tree: Challenge



+24V @ Pin 1 _____ **+24V @ Pin 5 _____**

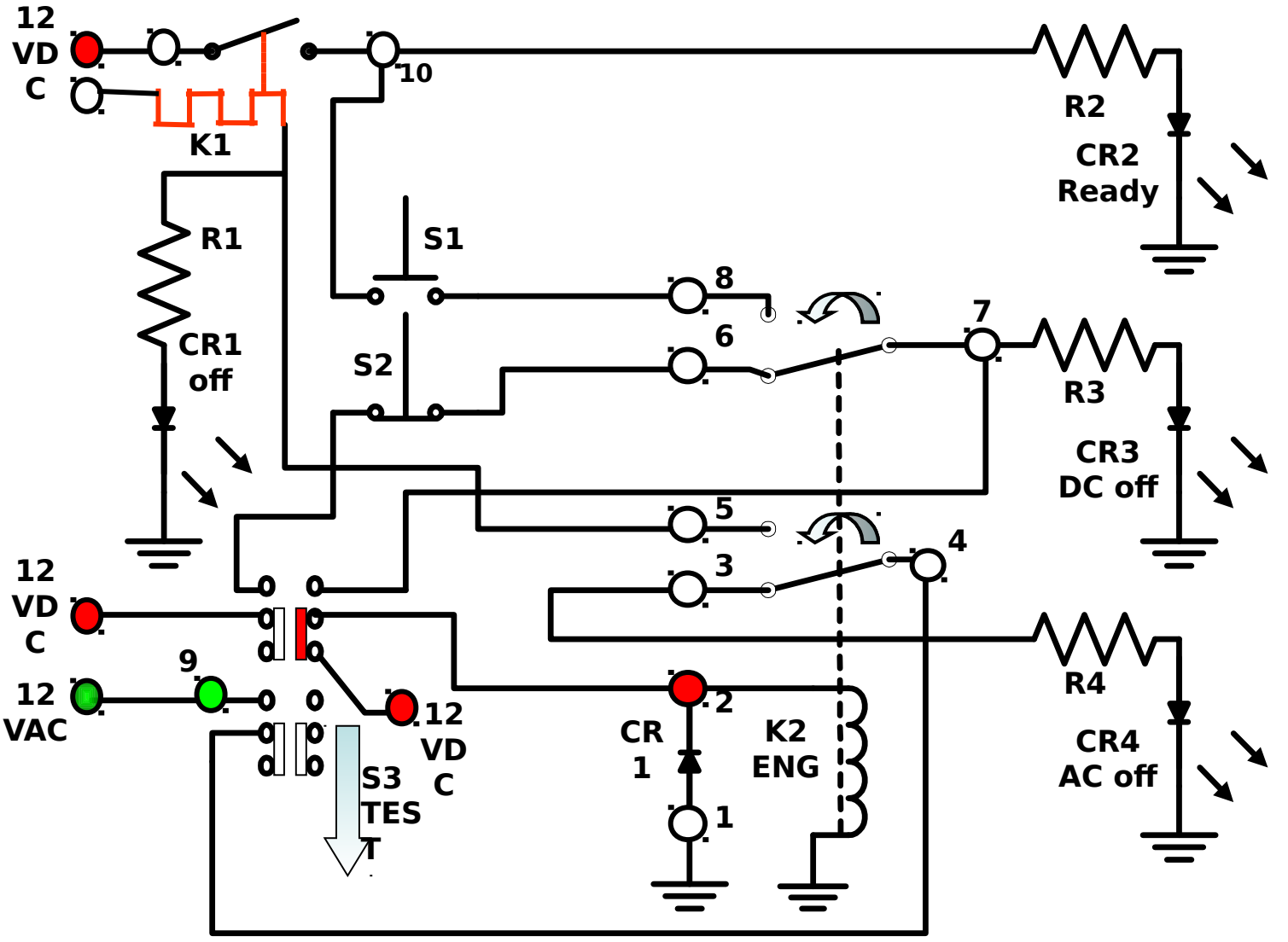
+24V @ Pin 2 _____ **+24V @ Pin 6 _____**

-12V @ Pin 3 _____ **-12V @ Pin 7 _____**

-12V @ Pin 4 _____ **-12V @ Pin 8 _____**

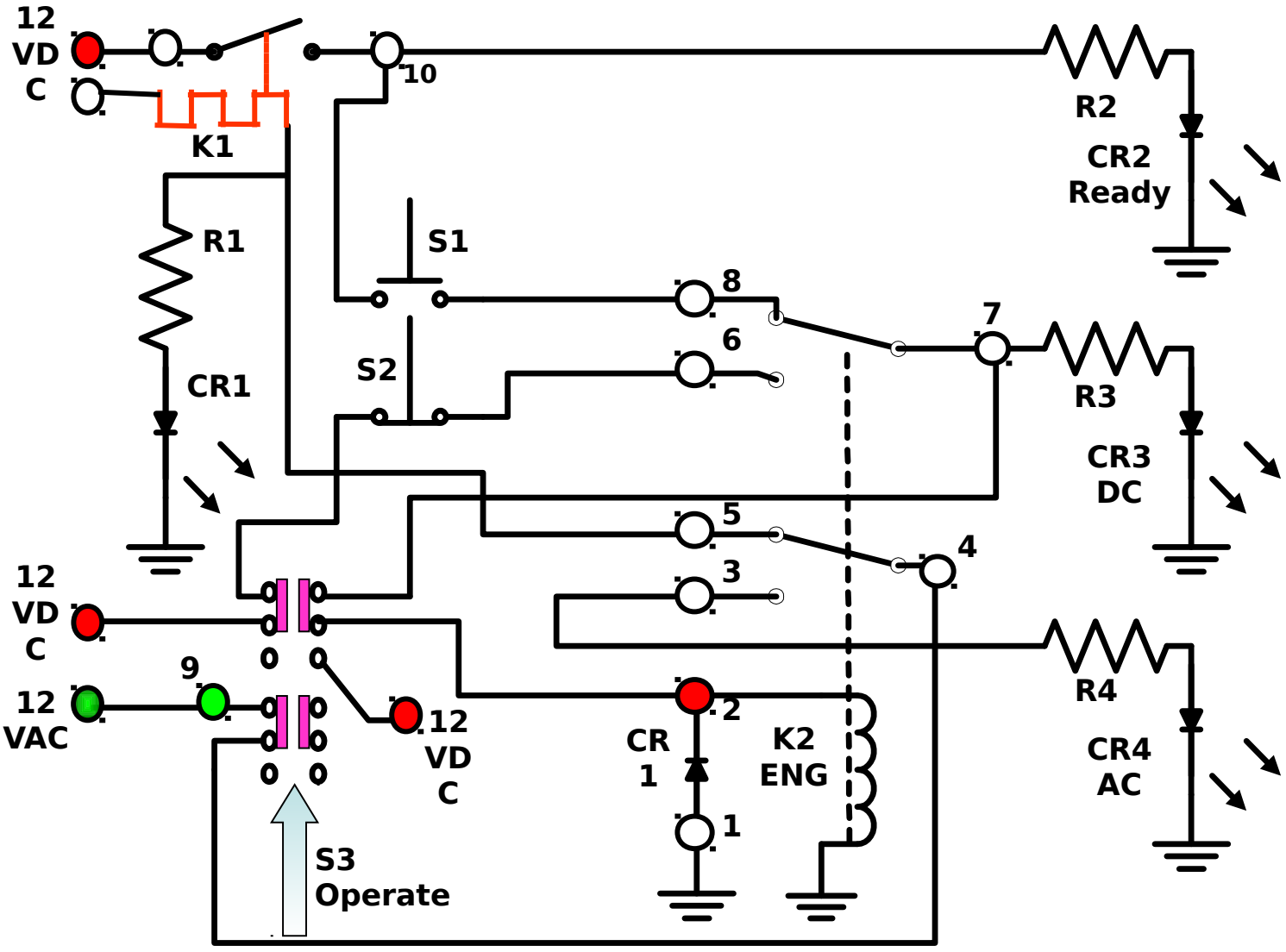
AC: Relays & Switches.

Control Device PC-130-71 ; S3, Test Position.



AC: Relays & Switches.

Control Device PC-130-71 ; S3, Operate Position.



AC: Relays & Switches.

JOB 1; ID the Relays & Switches in Figures 1-14.

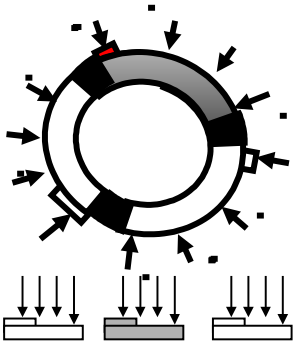


Figure 1

_____

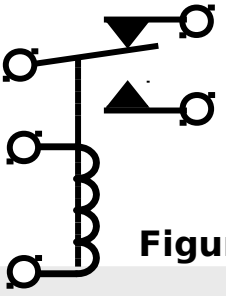


Figure 3

_____

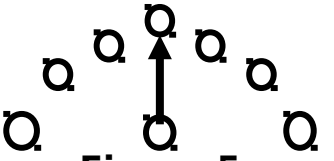


Figure 5

_____

Figure 7

_____

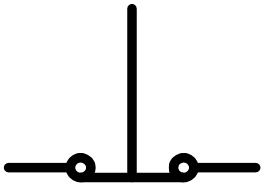


Figure 2

_____

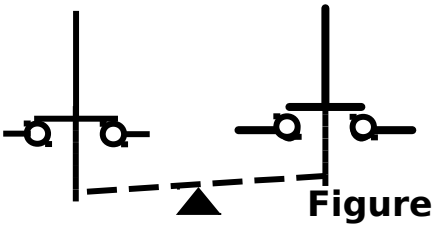


Figure 4

_____

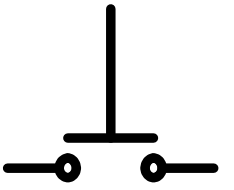


Figure 6

_____

Figure 8

_____

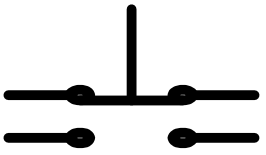


Figure 9

_____

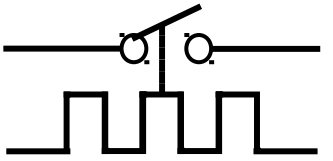


Figure 10

_____

Figure 11

_____

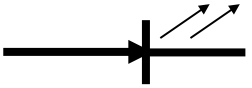


Figure 12

_____

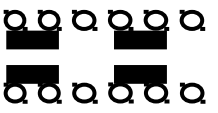


Figure 13

_____

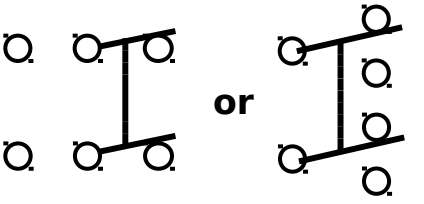


Figure 14

_____

AC: Relays & Switches.

JOB 2; Refer to Fig 15 for Questions 1-10.

1. Which Switches is closed when + 15 V is present @ pin 8. _____

2. Which Relays are energized when –6 V is present @ pin 4. _____

3. Which Relays are De-energized when +15 V is present @ pin 2.

_____

4. Which Relays are energized when –6 V is present @ pin 7. _____

5. Which Switches are closed when -6 V is present @ pin 1. _____

6. Which Relays are energized when +15 V is present @ pin 3.

_____

7. Which Relays are De-energized when +15 V is present @ pin 7.

_____

8. Which Switches are closed when -6 V is present @ pin 2. _____

9. Which Relays are De-energized when +15 V is present @ pin 5.

_____

10. Which Switches are Open when -6 V is present @ pin 6.

+15VDC
- 16VDC
_____

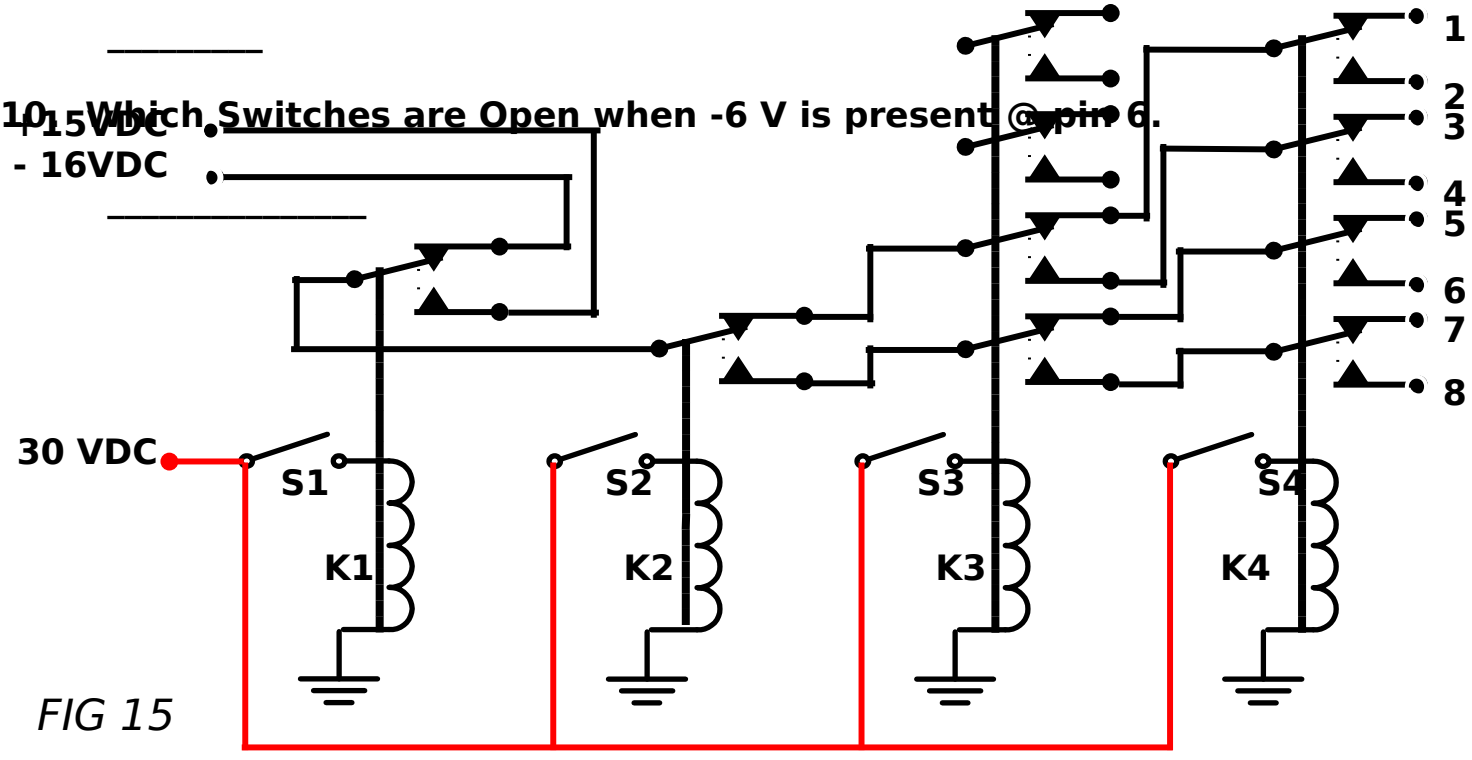
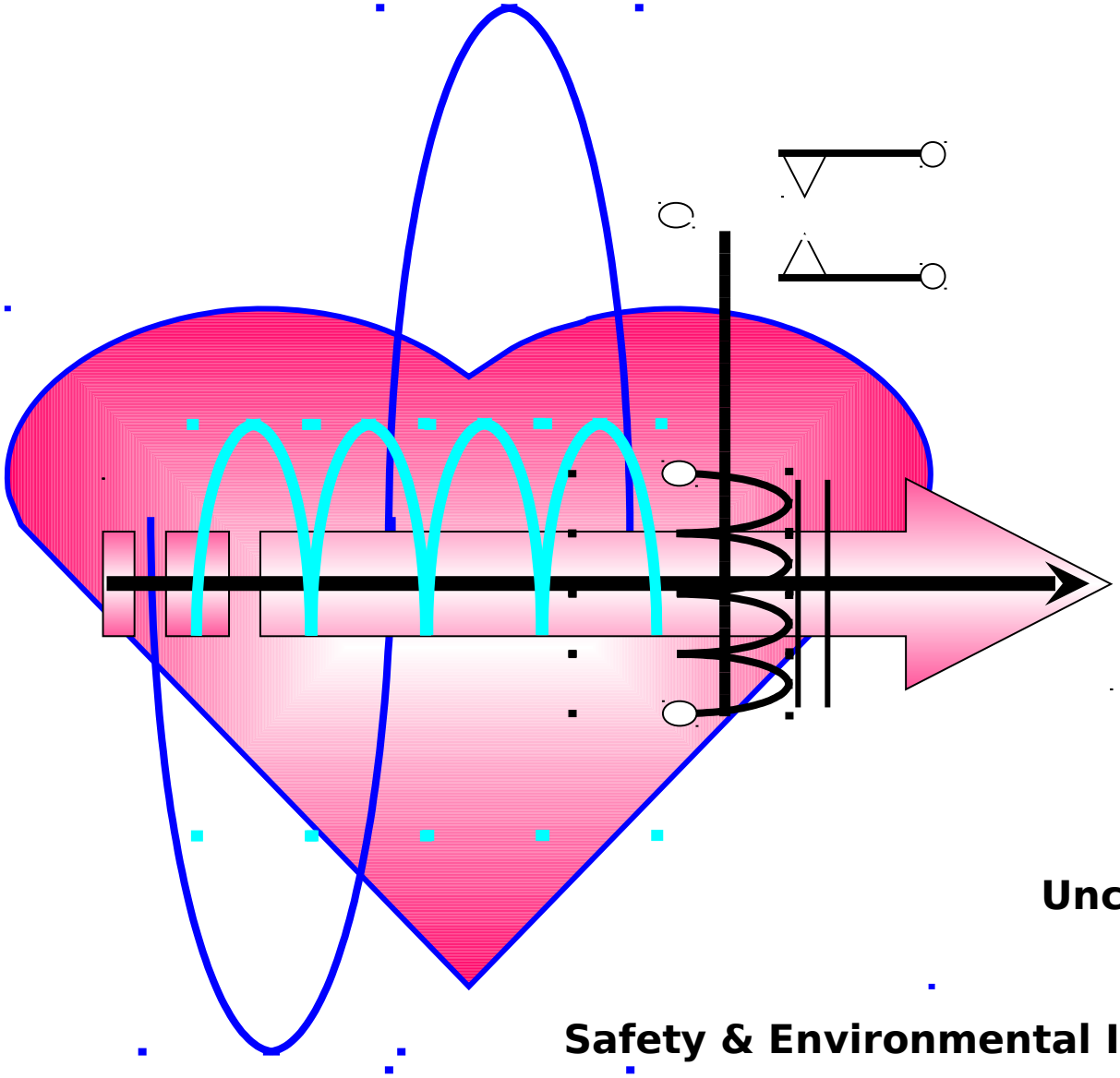


FIG 15

AC:

Electrical Circuits



Unclassified

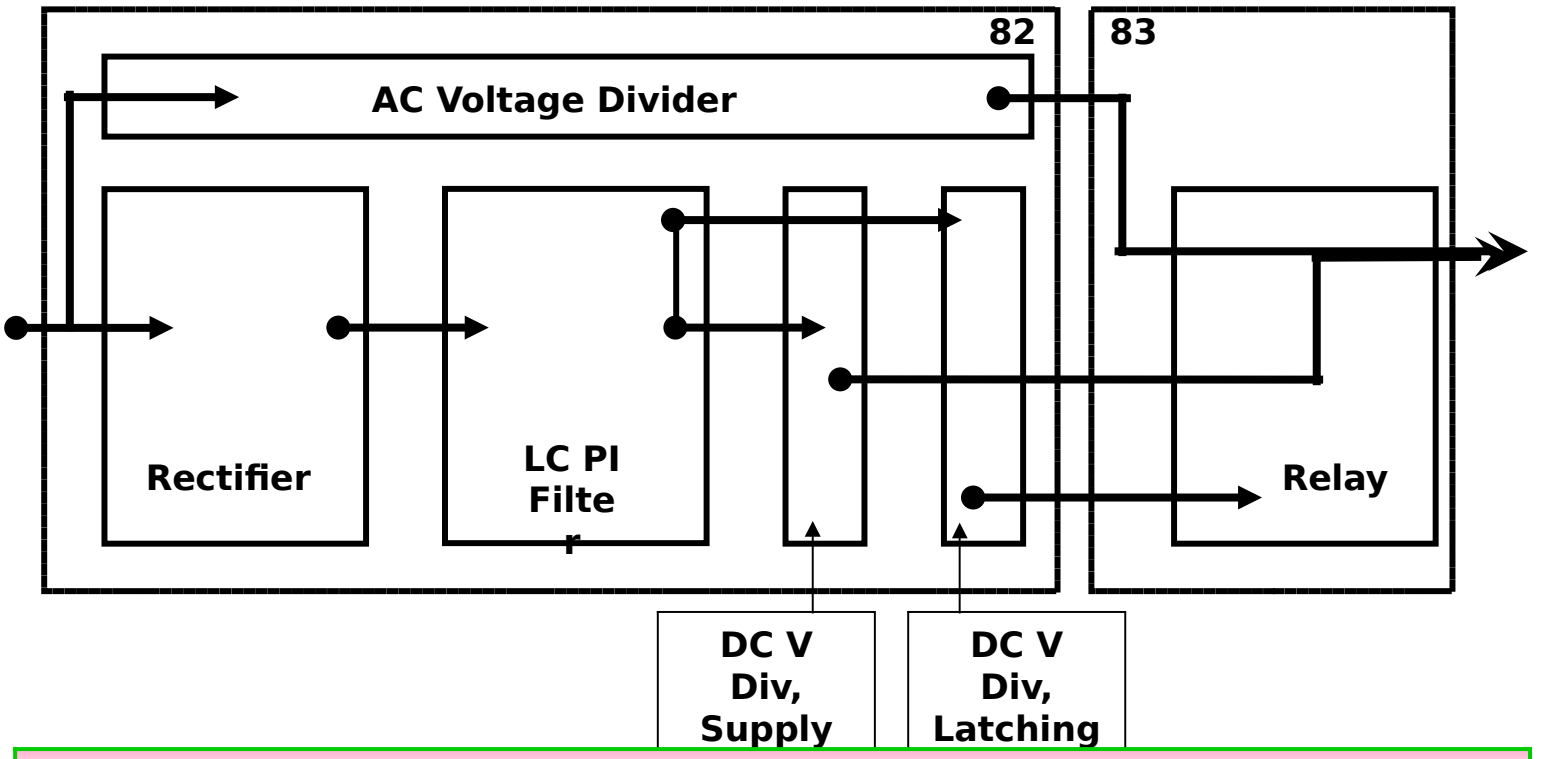
Safety & Environmental Impact is LOW

In previous lessons the concepts of individual component operation has been discussed, in addition simple Ckts have been examined to see how these components work together.

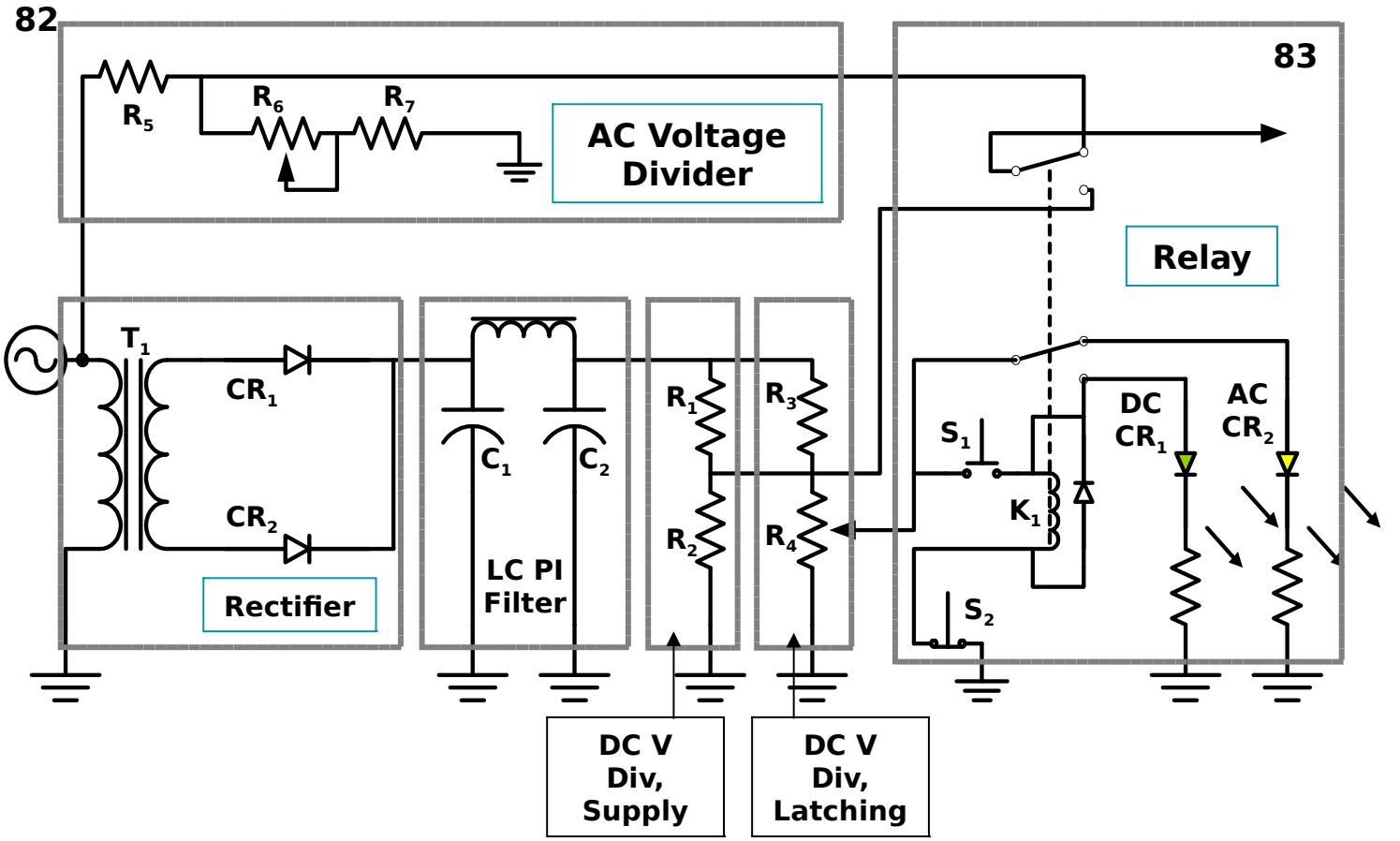
In this lesson we will use these components & Simple Ckts in combination, in a fully functional & practical application & examine how it all works together. Also how to Utilize correct trouble shooting procedures.

AC: Electrical Ckts

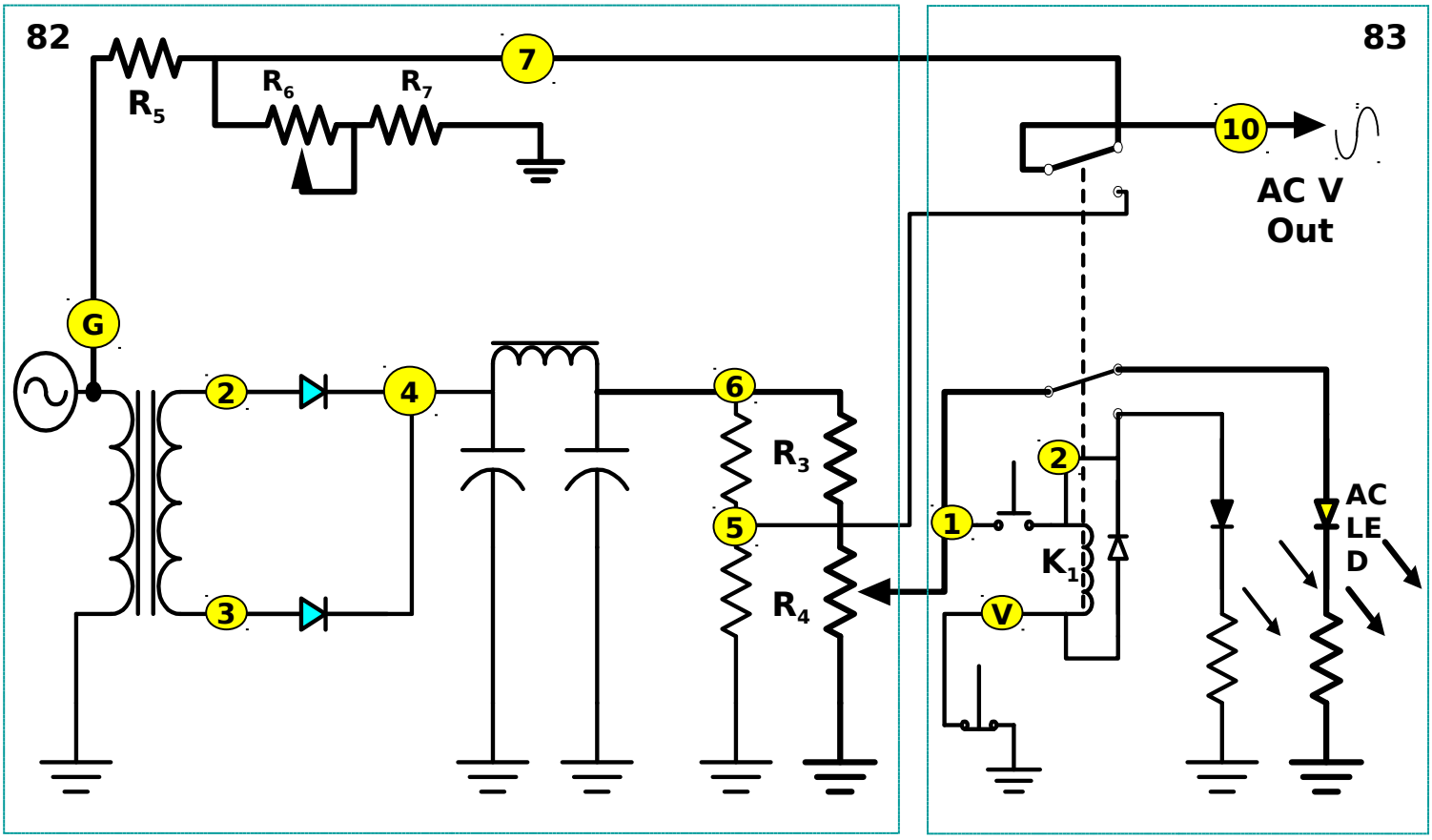
Block Diagram; PC 82 & 83 card



Block Diagram; PC 82 & 83 card , 6 Circuits.

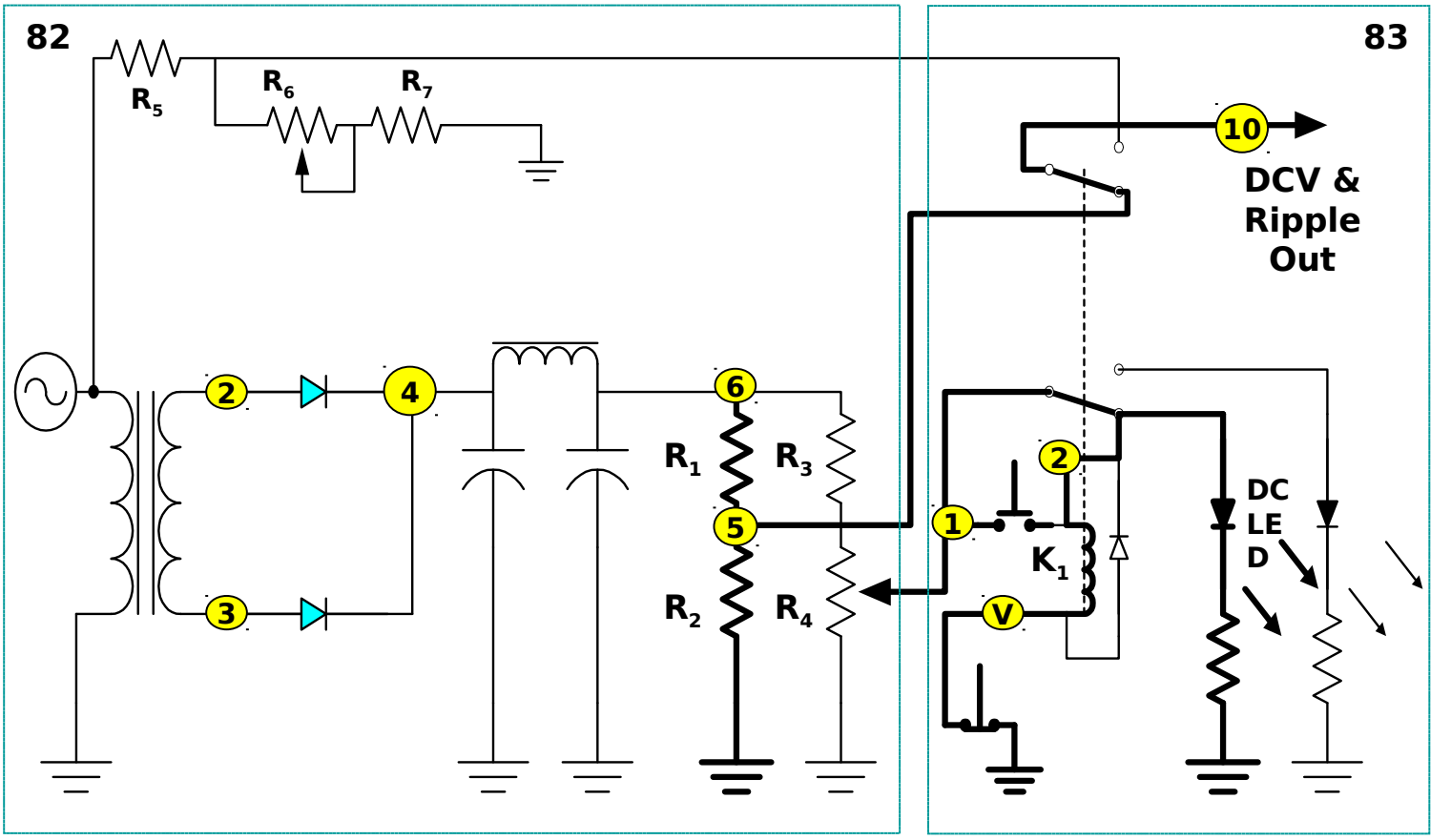


Schematic Diagram; Ckts Tracing, Denergized.

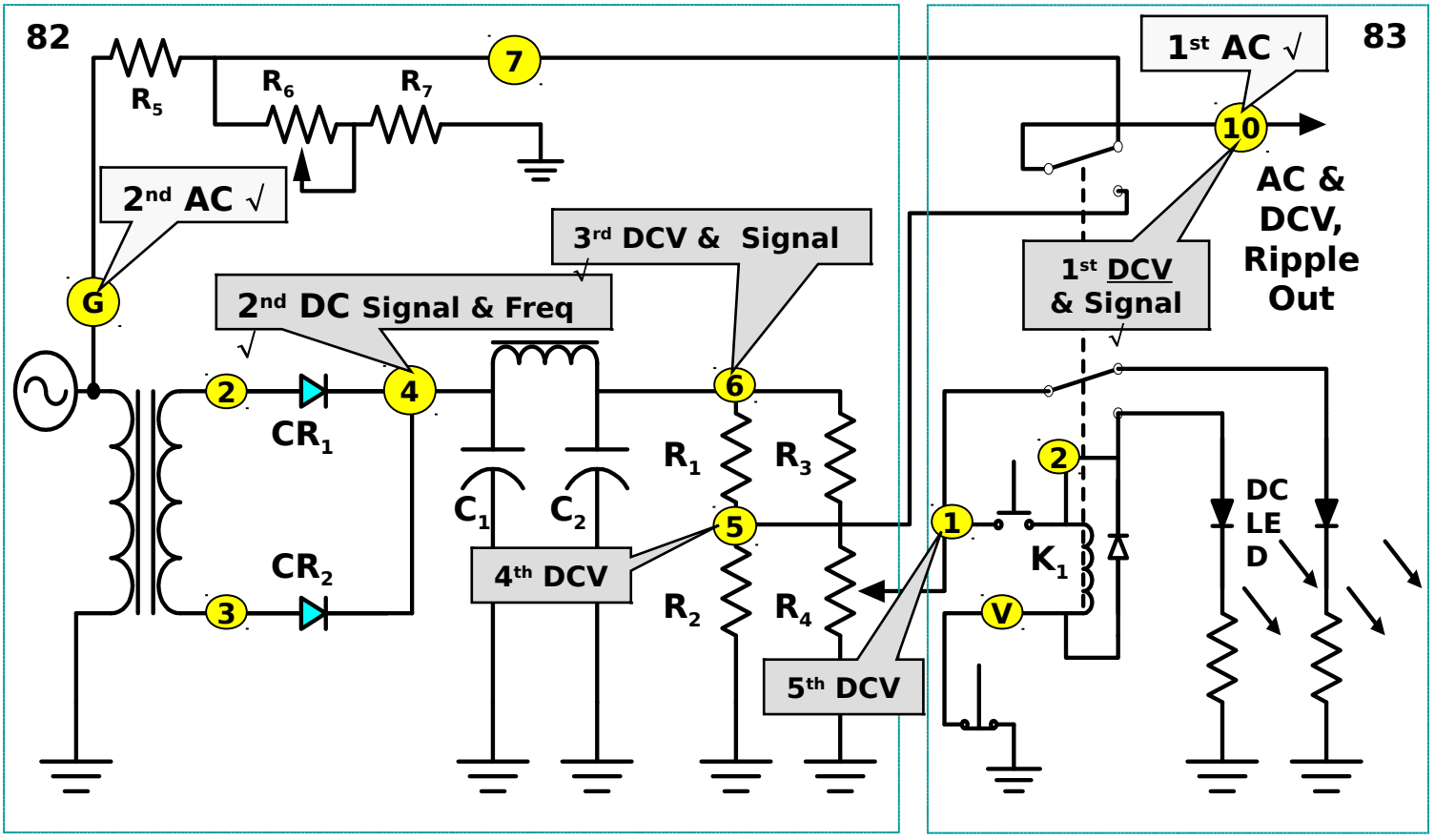


AC: Electrical Ckts

Schematic Diagram; Ckts Tracing, Energized.

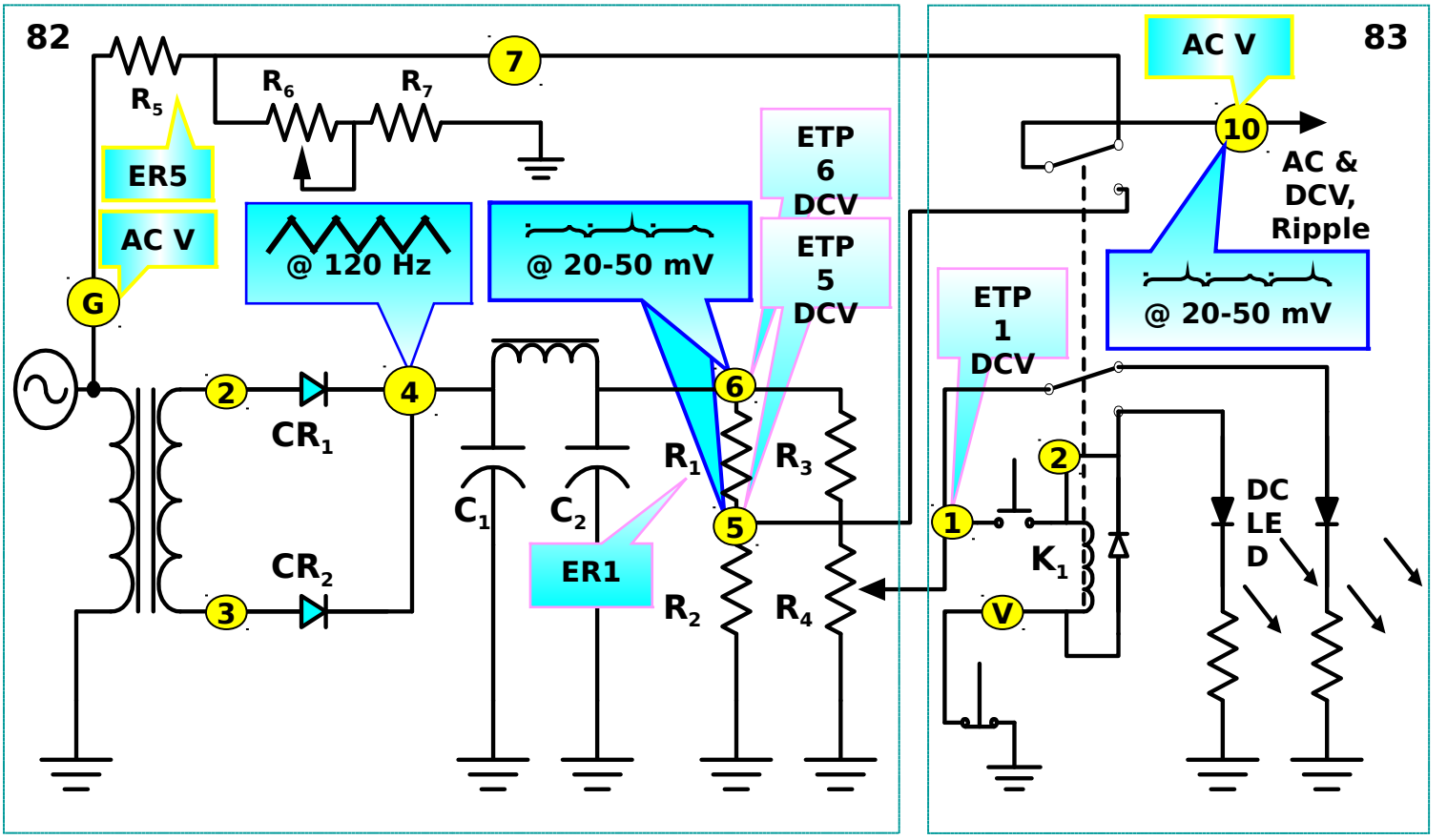


Schematic Diagram; Troubleshooting Sequence AC & DC.



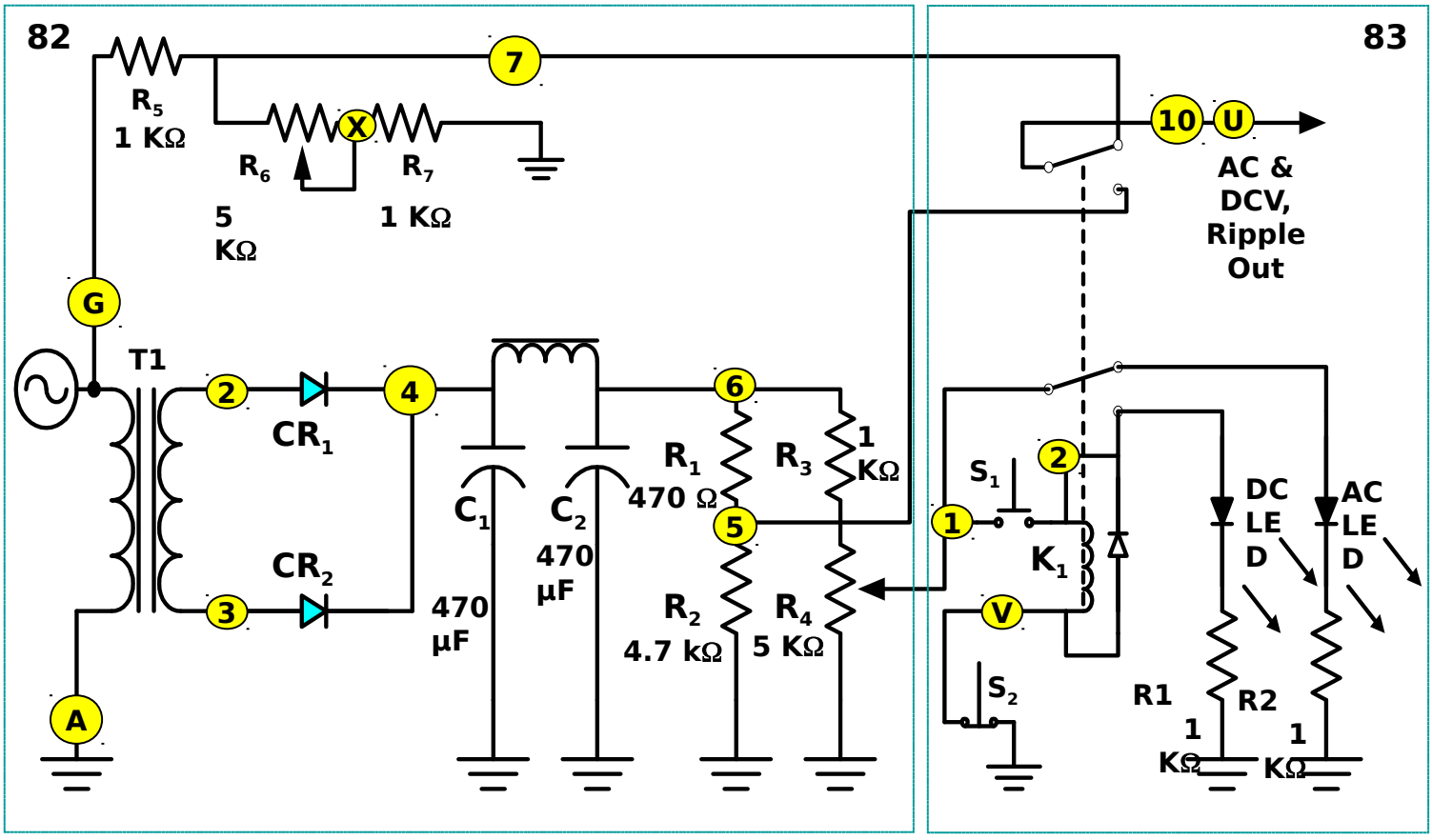
AC: Electrical Ckts

Schematic Diagram; Normals Required for T/S.



Note: An Energized & De-energized DCV is Required.

PC 82 & 83; Trouble shooting Challenge 1 & 2.



Challenge 1:

TP10; = 0 VAC

Pin G; OK.

Pin G / TP7; = Pin G

Malfunctioning Component _____

OPEN or SHORT ?

Challenge 2:

TP10; = OK VAC

TP4; = 60 Hz saw tooth

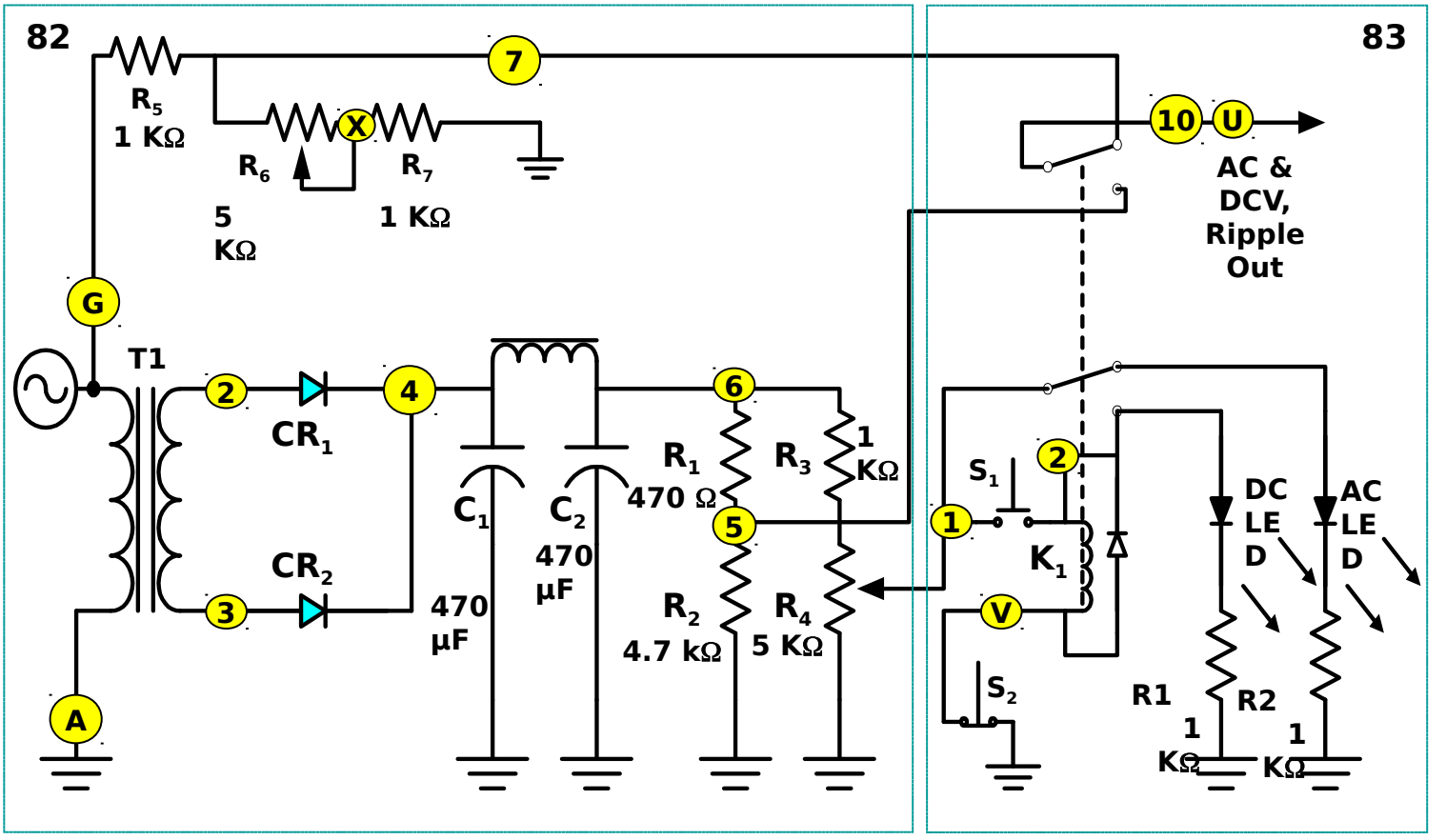
TP3; No HOOK

Malfunctioning Component _____

OPEN or SHORT ?

AC: Electrical Ckts

PC 82 & 83; Trouble shooting Challenge 3 & 4.



Challenge 3:

TP10; = VAC Ok, Ripple ↑

TP4; = Pulsating DC.

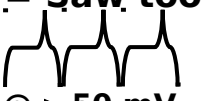
Malfunctioning Component _____

OPEN or SHORT ?

Challenge 4:

TP10; = VAC OK, Ripple ↑

TP4; = Saw tooth @ 120 Hz.

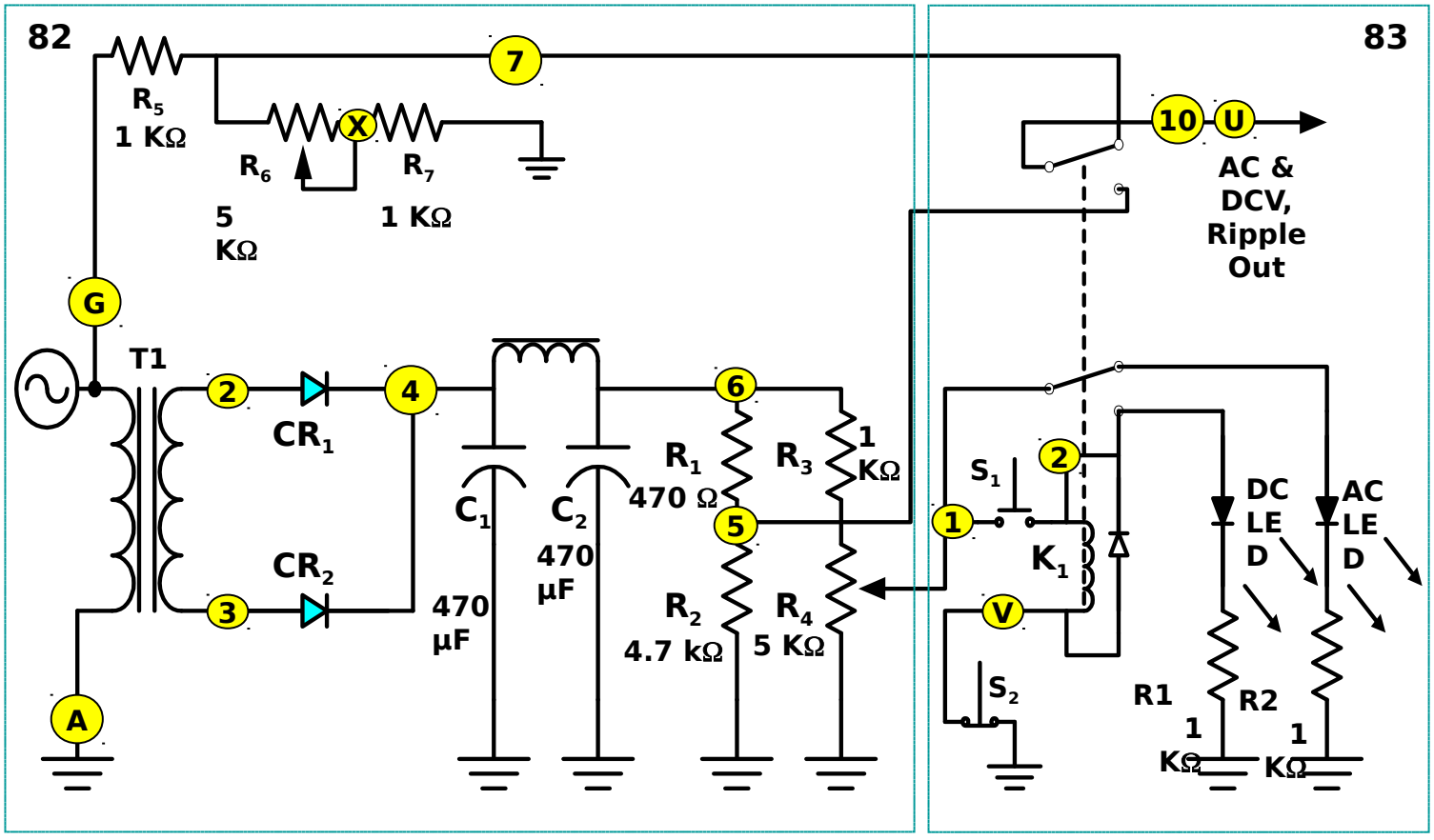


TP6; @ > 50 mV

Malfunctioning Component _____

OPEN or SHORT ?

PC 82 & 83; Trouble shooting Challenge 5 & 6.



Challenge 5:

TP10; = VAC Ok, Ripple 🡻, DCV = 0V

TP4; = Saw tooth @ 120Hz.

TP6; 20/ 50 mV, DCV🡹

ER1 = ETP6. R2 = 4.7 KΩ

Malfunctioning Component _____

OPEN or SHORT ?

Challenge 6:

TP10; = VAC Ok, Ripple 🡻, DCV = 0V

TP4; = Saw tooth @ 120 Hz.

TP6; 20/ 50 mV, DCV🡻

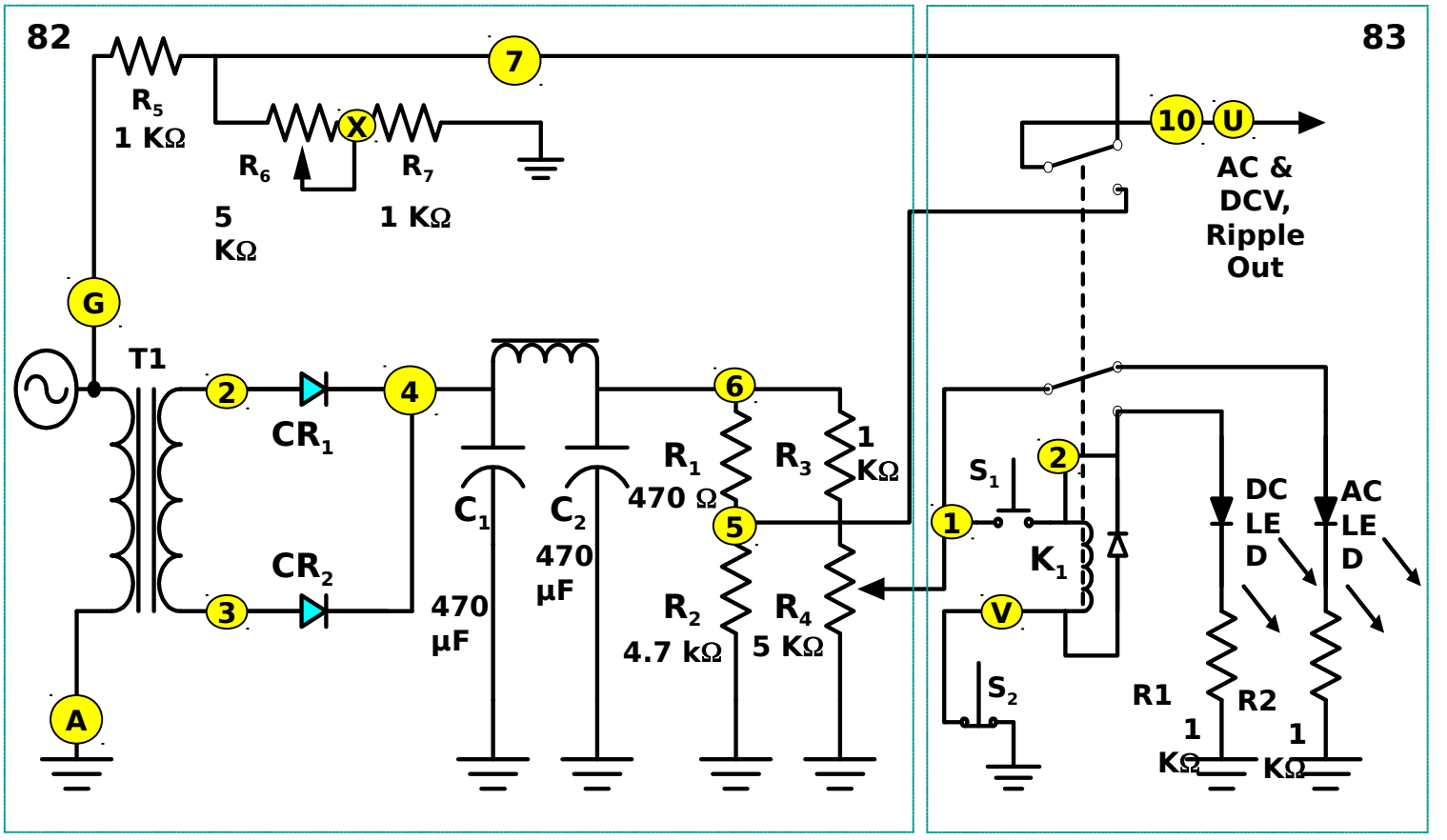
ER1 🡹 = ETP6. R2 = 0 Ω

Malfunctioning Component _____

OPEN or SHORT ?

AC: Electrical Ckts

PC 82 & 83; Trouble shooting Challenge 7 & 8.



Challenge 7:

TP10; = VAC Ok, Ripple ↑, DCV = ↑

TP4; = Saw tooth @ 120Hz.

TP6; 20/ 50 mV, DCV↑

ER1 = 0V. TP5 = TP6

Malfunctioning Component _____

OPEN or SHORT ?

Challenge 8:

TP10; = VAC Ok, K1 NO ENG

TP4; = Saw tooth @ 120 Hz.

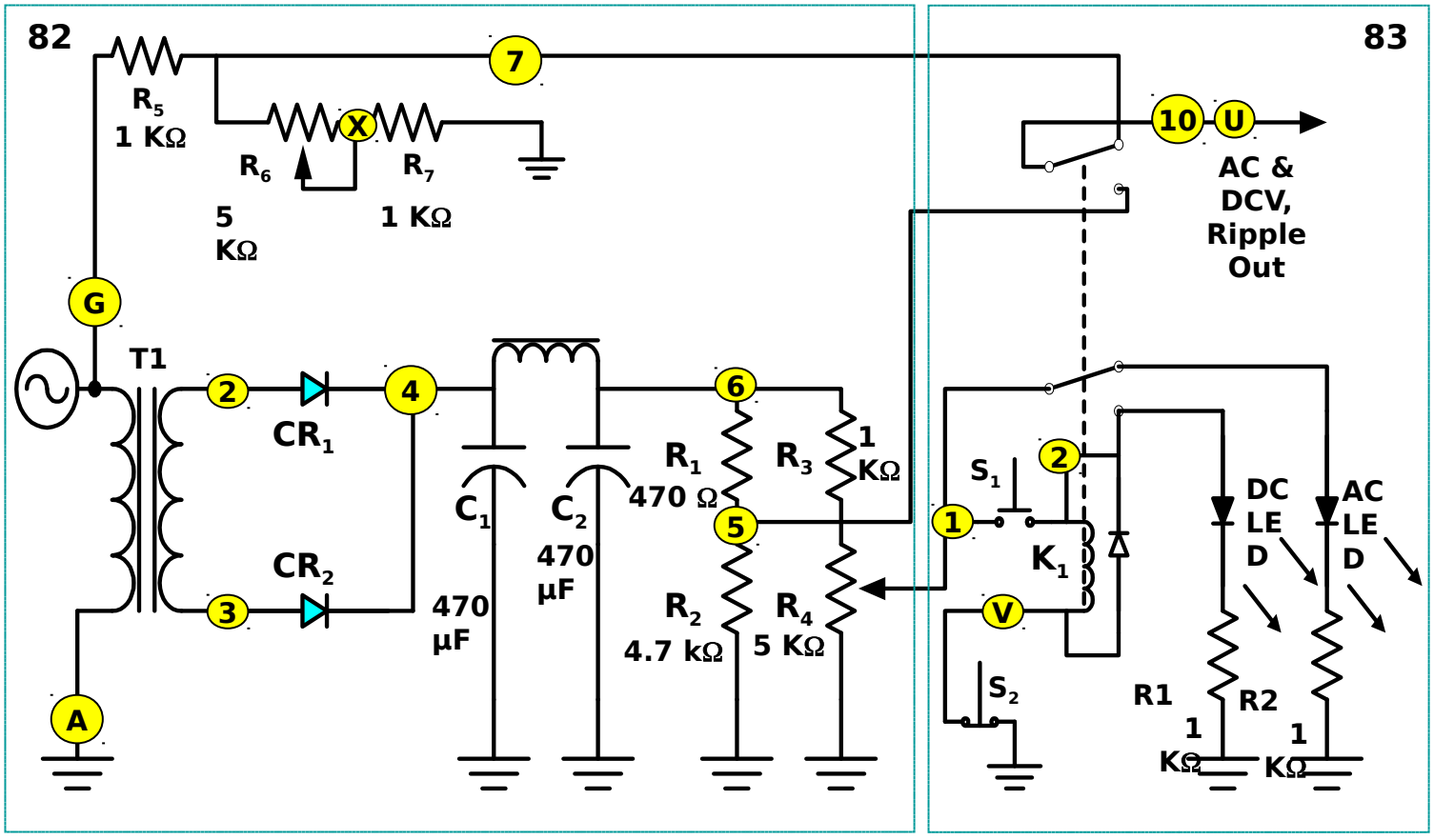
TP6; 20/ 50 mV, DCV↑

ETP1 = 0 V , ER3 ↑

Malfunctioning Component _____

OPEN or SHORT ?

PC 82 & 83; Trouble shooting Challenge 9 & 10.



Challenge 9:

TP10; = VAC Ok, K1 NO ENG

TP4; = Flat line , No Signal.

Malfunctioning Component _____

OPEN or SHORT ?

Challenge 10:

TP10; = VAC Ok, K1 NO ENG

TP4; = Saw tooth @ 120 Hz. DCV

↑

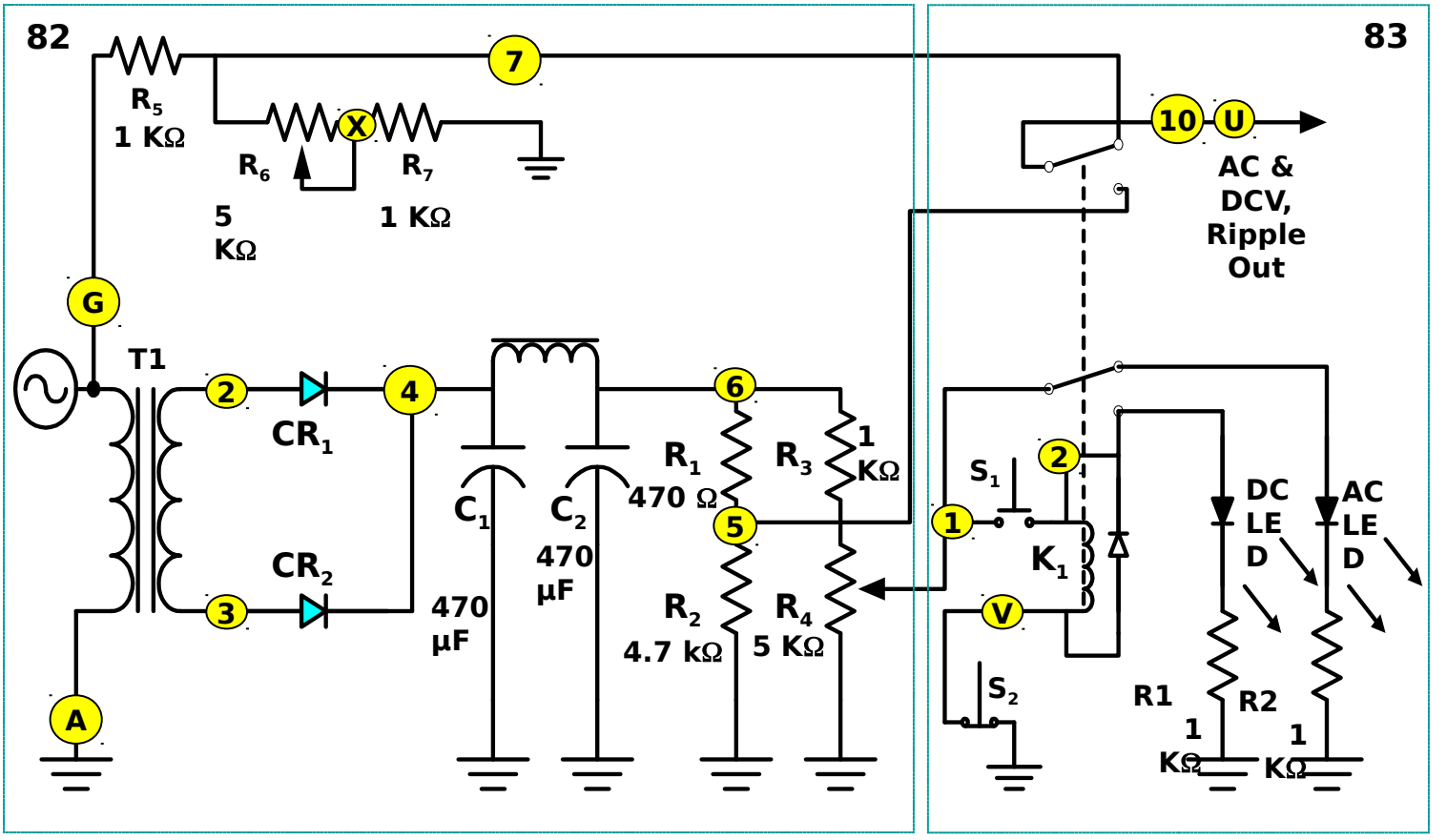
TP6; Flat Line, NO DCV

Malfunctioning Component _____

OPEN or SHORT ?

AC: Electrical Ckts

PC 82 & 83; Trouble shooting Challenge 11.



Challenge 11:

TP10; = VAC Ok, K1 NO ENG

TP4; = Saw tooth @ 120 Hz.

TP6; = 20/ 50 mV, DCV Norm.

TP1; DCV Norm.

S2 = Hi/Hi M Ω.

Malfunctioning Component _____

OPEN or SHORT ?

PE Setup; PC 83 & 83.

1. **PC 82 Card on PC1 position.**

   S1 Up to Ind.

2. **PC 83 Card on PC2 position.**

3. **Turn AC "ON" on PC1.**

   Enter Defaults F104, F114, F204. *Must be loaded @ all times*.

   Adjust R6 [82 card] for 11 VAC @ TP7.

   Adjust R4 [82 card] for 13 VDC @ [TP1 on 83 card]
   ***Deenergized mode*.**

4. **Record Normals.**

Shoot Bugs.
130A to
then the new Bug

Note: after each bug **reset** trainer, Wait for appear then insert all 3 defaults number.

On Breaks, Turn the trainer "OFF" so it can cool down.

Bug {malfunction} Numbers;

E-104	**F-107**	**F-102**
F-113	**F-111**	**F-108**
F-110	**F-205**	

AC: GLOSSARY; A - B.

A

Absolute Value Number**.**
The numerical value of a number without the + or - polarity indicator. Example; -**7** absolute value is **7**, + **7** absolute value is 7.

Alternating Current .
Current that flows in one direction then in the other. Or current that changes in Amplitude & Periodically reverses direction. AC current will flow toward the most positive point in the Ckt, the difference w/AC is, the polarity will alternately change.

Alternation +or **-**

The Positive or Negative half of a signal. ½ of a period

Amplitude

Abbreviation; Amp. Unit of measurement for current. Symbol; I.

Analysis. [In troubleshooting].
A detailed cause & effect explanation of a malfunctions and its effects on the Ckt.

Attenuation.
Is the Reduction in magnitude of any electrical parameter of a signal.

B

Bias.
Is the difference of potential between 2 points or elements. Bias has 2 states of operation, forward & reverse.

Bias (Forward).
When the polarity of the signal agrees w/ the polarity of the material, current flow is maximum, resistance is minimum.

Bias (Reverse).
When the polarity of the signal DISSAGREES w/ the polarity of the material, current flow is minimum, resistance is maximum.

C

Capacitance.

The Value of a capacitor is determined by several factors & provides the mathematical constant for the value of the Cap. The area of the plates; [*surface area*] Distance between the Plates; The greater the distance between the plates, the less the capacitance. [*The effect of charged particles is less as distance increases*]. Type of dielectric; Air, Mica, Glass, Quartz, Castor oil, Vacuum.

Capacitive Reactance.

Capacitors like Inductors are frequency sensitive devices. Since their opposition cannot be measured it must be calculated with Frequency as part of the equation.

1 = XC in Ω (*1 Over 2 Pies For Chow)*

2π FC 6.28 X Frequency X Capacitor 1/X ⇒ XC

Caps, (3 Types).

FIXED, ELECTROLYTIC & VARIABLE.

CAP Electrolytic.

Wiring integrity must be observed. The Negative side must be oriented toward ground. The polarity is usually indicated on the case, or there is a black strip indicating the Negative lead. Wiring in reverse creates a Hazard.

CAP, (3 Basic Parts).

2 Plates & Dielectric; A Dielectric is a solid, liquid or gaseous material that can sustain an Electrostatic Charge and act like an Insulator.

Center Tap. (Transformer).

By placing a ground in the center of the secondary winding, two voltages of the same amount but opposite in polarity are provided.

Coupler (LR)**.**

The TC/PW is Long (≥ 1/100). The Output Component is the Inductor. Output Waveform is Square wave.

Coupler (RC).

An RC circuit where the Output taken across the Resistor, TC/PW ratio is Long, Output waveform is Square.

CT, (Calculating for).

The objective is to reduce the capacitor values down to a single value of Capacitance { CT }. The method for determining CT is just the opposite of the resistor, RT.

AC: GLOSSARY; D - E.

D

Differentiator (LR).

The TC/PW is Short (≤ 1/10). The Output Component is the Inductor. Output Waveform is spiked

Differentiator (RC).

An RC circuit where the Output taken across the Resistor, TC/PW ratio is Short, Output waveform is Spiked.

Diode.

Sometimes referred to as a crystal. Advantages; small in size, low voltage ops, uses less power. Disadvantages; sensitive to heat & high voltage. Letter symbol; CR or D, CR1 . commonly used as a rectifying device in a Pwr supply. Allows current to flow in only one direction.

Diode (ark suppression).

Commonly used w/a relay to give current a path to ground from the collapsing magnetic field on the coil. Suppresses the tendency of the contacts on a relay to arc.

E

EA. (Voltage Applied in a Ckt where the oposition was added Vectorally)

ER1 + EL1 does not = EA, The opposition was Added Vectorally. Therefore the Voltage drops must be Added Vectorally. The Pythagorean Theorem is used as it was in solving for total opposition.

Electromagnetic Relay.

An electromechanical device used for the routing of voltage, current, & power W/O human exposure to high voltages & current. W/1 switch numerous switches can be made (turned on). Power up procedures made in sequential order, thus eliminate possible Ckt damage or human error. Remote location switching made possible. Schematic symbols; **K_1 ...** NOTE: relays on the schematic are drawn in the de-energized position.

Equivalent Values of AC Voltages.

AC Voltage have 3 different numerical values for the same Voltage. 1. Peak [pk] 2. Peak to Peak [PP] 3. RMS or Effective [VAC]

AC: GLOSSARY; F, G, H.

F

Ferrous Materials;
Iron or Iron based Materials,

Filter.

Converts pulse-sating DC from the rectifier, to Ripple DC & raises the DC voltage level.

Flux Lines

The Magnetic Field or lines of Force that is created as Current flows through a conductor.

Frequency.

Is the number of complete revolutions [360o] of the Generator in 1 Second.
Unit of Measure; Hertz, Hz, [KHz].

Function Generator [Sweep].
Test equipment capable of varying amplitudes & frequency's of AC. Sometimes referred to as an AC source.

G

Generator.

Converts mechanical energy to electrical energy by the conductor loop cutting through the Magnetic Field inducing Voltage & Current.

H

High Pass Filter.
Passes high frequency W/Maximum Voltage. Attenuates the low Freq. Attenuation is the Reduction in magnitude of any electrical parameter of a signal. The Output is taken across the Inductor.

AC: GLOSSARY; I.

I

IMPEDANCE.

TOTAL OPPOSITION to the flow of AC Current. Symbol; **Z**
Unit of Measure; **Ω**. In a Ckt containing more than one type of Opposition, a non-reactive component & reactive component TOTAL OPPOSITION will have to be calculated for.
(A *Resistor, no change value w/ the change in frequency* & *and a Inductor, that changes value {XL} w/ the change of frequency*).

Impedance (LCR).

Is the total Opposition to AC, Units in Ω. Because of the 180º Out of Phase relationship of the XL & XC the difference must be calculated. If they are Equal, they will cancel each other out, and only Resistance remains.

Formula; $\mathbf{Z = \sqrt{RT^2 + \{ XL - XC \}^2}}$

Impedance matching.

For maximum power output. Used to match impedance between two circuits because the number of turns on the primary and secondary windings can be controlled in manufacturing.

Inductor.

By winding a conductor with in a small area and concentrating the magnetic field, an Inductor is produced. An Inductor opposes any change in Current & stores energy in an Electromagnetic Field. It may be called a Choke or a Coil.
Inductor Symbol; L. Unit of Measure; henrys, h *lower case* , mh milli henrys. 3 types; Air, Iron, [*Fe, Ferrite*] & Variable.

Induce or Induct.

The ability of an inductor to store energy in an electromagnetic field and return that energy to the Ckt, in the form of Current. This ability is dependent upon change. AC offers the change to convert Current Energy to Electromagnetic energy, then back to Current. This occurs with the change of polarity of the AC wave form.

Inductive Reactance (XL).

The opposition of an Inductor to AC. Unit of Measure; Ω Ohms
2 π F L, *2 Pies For Lunch* **2 π X Frequency X Inductor**

In Phase.

Voltage across a Resistor & Current are in phase. Both entity's start @ the same time and end @ the same time.

Integrator (LR)**.**

The TC/PW is Long (≥ 10/1). The Output Component is the Resistor. Output Waveform is Triangular.

Integrator (RC).

An RC circuit where the Output taken across the Cap, TC/PW ratio is Long, Output waveform is Triangular.

AC: GLOSSARY; L - M.

L

LED.

Light emitting diode, commonly used as indicator lights on electrical equipment.

LR Ckt.

A Ckt comprised of a Resistor & Inductor in series, where the rate [time] of Expansion & Contraction is dictated by the value [size] of the Resistor & Inductor.

LCR.

A Ckt comprising of an Inductor, Capacitor & Resistor.

LT, (Inductor Total) **.**

The total inductance in a circuit. Inductance is calculated like resistors and depending on the type of circuit *Series, Parallel, & series-parallel*. will dictate how LT is calculated.

Law of Magnetism.

Opposite's Attract, Like's Repel.

M

Mutual Inductance.

The process of transferring the energy from the primary to the secondary coil is due to the expansion & contraction of the magnetic field on the primary, cutting across the secondary, Inducing voltage & Current upon it.

Magnite

Describes how the measurement is being taken. Example; The Leads are placed on each side of [Bracket] the Resistor for a measurement.

The term is use in calculating the reduction of voltages @ Test Points to voltage drops the term Bracket is used w/ subtract, Bracket & Subtract

AC: GLOSSARY; O - P.

O

Oscilloscope.

Test equipment, capable of measuring period and amplitude of an AC wave form over a wide range of frequencies and voltage. These are displayed in a visual format. Some are capable of measuring DC.

Out of Phase.

Describes 2or more entity's starting and stopping @ different times, usually expressed in degrees. Example; The EL is Leading the Voltage across a Resistor by 90o. Or the ER is Lagging the EL by 90o.

P

Period;

The amount of time required for the rotor to make 1 complete revolution. In units of Seconds [Sec], [μS].

Period to Frequency.

If Period is known, Frequency can be calculated. 1/ Period or [Period 1/X] ⇒ Freq In [Hz].

Frequency to Period.

If Frequency is known, Period can be calculated. 1/Freq or [Freq 1/X] ⇒ Period In [SEC].

Power (Transformers)**.**

Power is a product of Voltage & Current, **E X I = P**, measured in units of watts. Transformers will be considered 100% efficient, Power in, is equal to, Power out. $\mathbf{E_P X I_P = P_P}$ **,** $\mathbf{E_S X I_S = P_S}$**.**

Power Supply.

Changes the AC line voltage to the required DC operating voltages for the designated equipment. It can be + or - or both.

Pulsating DC (PWR supply)**.**

The output of a rectifier w/o the filter attached. Seen & measured W/the O-Scope.

Pulse Width. (PW).

PW = one over two times the frequency. 1 / 2F or PW = 1/ 2 X Freq. ½ of the period or is the same as one alternation. Can be positive or negative.

Pythagoreans Theorem.

Referred to as Vectored Addition. $A^2 + B^2 = C^2$. $\sqrt{Z}$

Redefined for calculating Impedance;

$= RT^2 + XL^2$

R

Ratio, Turns (transformers).
The number of turns or winding on the primary versus the secondary. The turns ratio is the mathematical constant used in determining either the primary voltage/current or secondary voltage/current. The turns ratio is always reduced & expressed in the lowest terms with one of the numbers being 1. The largest number represents how many times greater the voltage is than the voltage of the smaller number.

RC Ckt.
A Ckt comprising of a Resistor & Capacitor in series where the rate (*time*) of Charge & Discharge is dictated by the value [size] of the Resistor & Cap.

Rectifier.
Changes the AC output of the transformer to "PULSATING DC". Allows current to flow in 1 direction, it acts like a one way valve, or one way current device. It can be a half wave or full wave rectifier.

Reactance.
The value of opposition in a frequency sensitive device. The opposition will change as the frequency changes. Since its value cannot be measured, it must be calculated, with frequency as part of the equation.
Symbol; **X**. Unit of Measure; Ω Ohms

Relay (Thermal Time Delay).
Contacts Make @ a predetermined temperature. Provide for Ckts to warm-up before full conduction or current flow.

Relay Tree.
More than one relay connected to close (make) or open (Break) or a combination of both from a single switch or device.

Ripple DC (PWR supply).
The Natural output of the Pwr Supply. Seen & measured w/ the O-Scope.

RMS; {Root Mean Square}.
Also called the Effective Voltage {EFF}. Its name is derived from the constant .707 or 70.7% which is the value of percent of AC required to do the same work as DC. RMS, Read the Meter Student! If a value of voltage is expressed as VAC it is professionally understood as the RMS AC Voltage.

AC: GLOSSARY; S - T.

S

Sawtooth (troubleshooting)**.**

A waveform in the triangular type. Is the reflection of a cap charge & discharge as seen on the oscilloscope in and RC type Ckt & filter.

Sine wave.

Is the Voltage Generated in relation to the angle or position of the rotor in the magnetic field.

T

TC, (LR Ckt)**.**

TC = Time for current to reach approximately 63% of maximum expansion. A total of 5 TC is required to reach 100%. **L÷ R = TC** in µS only.

TC to PW Ratio.

The TC tells us how much time is NEEDED to charge a Capacitor to 63% of the Applied Voltage. The PW tell us how much time we HAVE to charge a Capacitor to 63% of EA.

Time Constant, (TC (RC Ckt).

The rate [time] of Charge & Discharge dictated by the value (*size)* of the Resistor & Cap. The TC is measured in units of µ Sec only. 1 Time Constant [TC] is the amount of time required for a Capacitor to charge to 63% of the Applied Voltage. **TC = R X C** in Micro Seconds. A total of 5 TC is required to reach 100%.

Transformer.

Changes the AC input Voltage and Current from one value on the input to a different value on the output.

Two Core Types; Iron core used with audio frequencies [AF] between 20 Hz & 20 KHz. Commonly used in power applications. Air core used with radio frequencies [RF] 20 KHz and above. Application is seen where signal transfer & information is required.

AC: GLOSSARY; T - V.

T

Transformer (Auto)**.**

Autotransformer comes from the automatic voltage regulation they provide. Despite changes in load current, the opposing currents strike a balance which causes a stable output voltage to exist. Have only one winding & a common wires for the primary and secondary. Both the primary and secondary currents flow through the same wire. Commonly used in sewing machines and electric train controls. Disadvantage; no isolation between the circuit and the line.

Transformer (Multiple windings).

Capable of Providing several different output voltages on the Secondary.

Transient Waveform.

A waveform that changes from one steady state to another or is positive for a period of time, then Negative for an equal period of time. A Sine wave is not a transient waveform.

Troubleshooting (½ Split Method).

Method of troubleshooting to quickly find the malfunctioning Ckt among many Ckts. Output, input, ½ split.

V

Vector.

Is the mathematical expression of phase relationships in a circular profile w/ extending rays that describe different electronic entity's any where from 0º to 360º. To read a vector, read counterclockwise, the entity that reaches the 12:00 position 1st, is leading.

Vector, (Reading a).

Rotating in a counter clockwise direction, entity A is leading B by 90o. The length of the RAY expresses the Amplitude of the entity.

AC: Student Grade Sheet.

AC:	LESSON	Test	Average
AC:	Intro To AC & Freq		
AC:	Test Equipment		
AC:	Resistive Circuits		
AC:	Inductive Circuits		
AC:	Capacitors		
AC:	Transients in RC Circuits		
AC:	Transients in LR Circuits		
AC:	LCR Circuits		
AC:	Transformers		
AC:	Power Supplies		
AC:	Relays & Switches		
AC:	Electrical Ckts		
AC:	Unit Exam/Block Test. W/		PE/

AC:

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